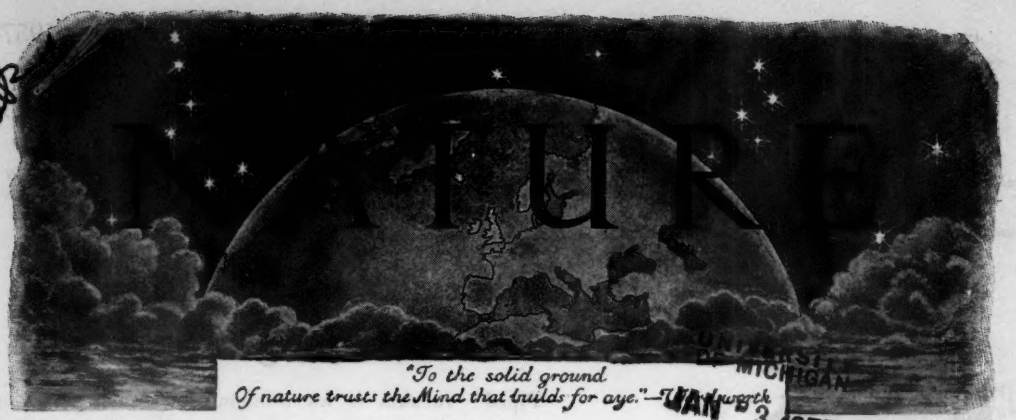

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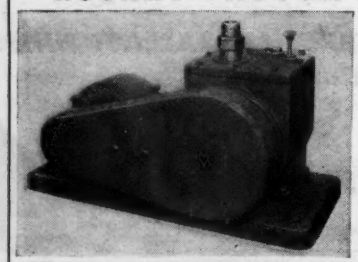

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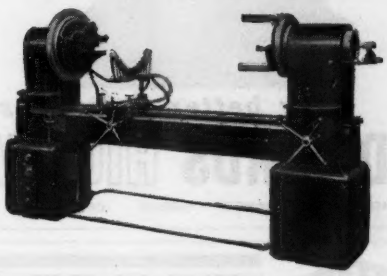

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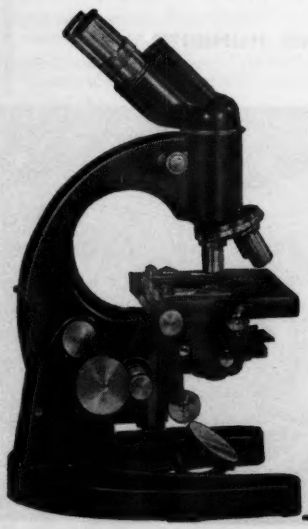

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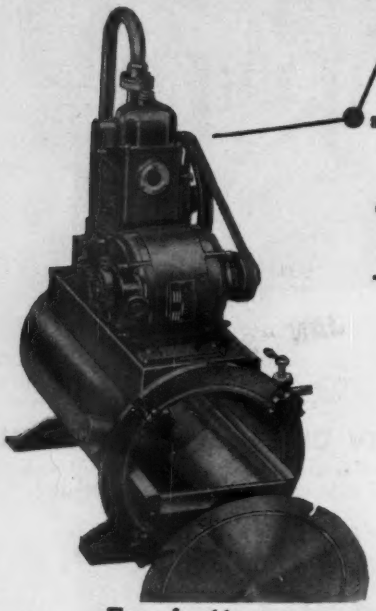

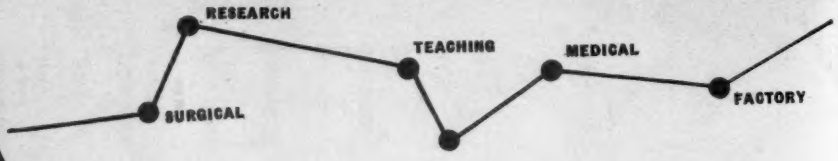

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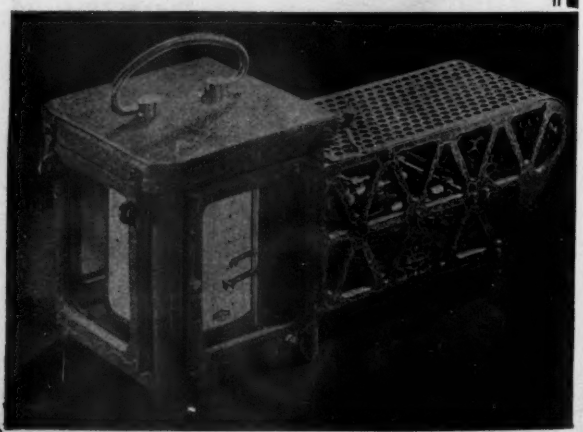

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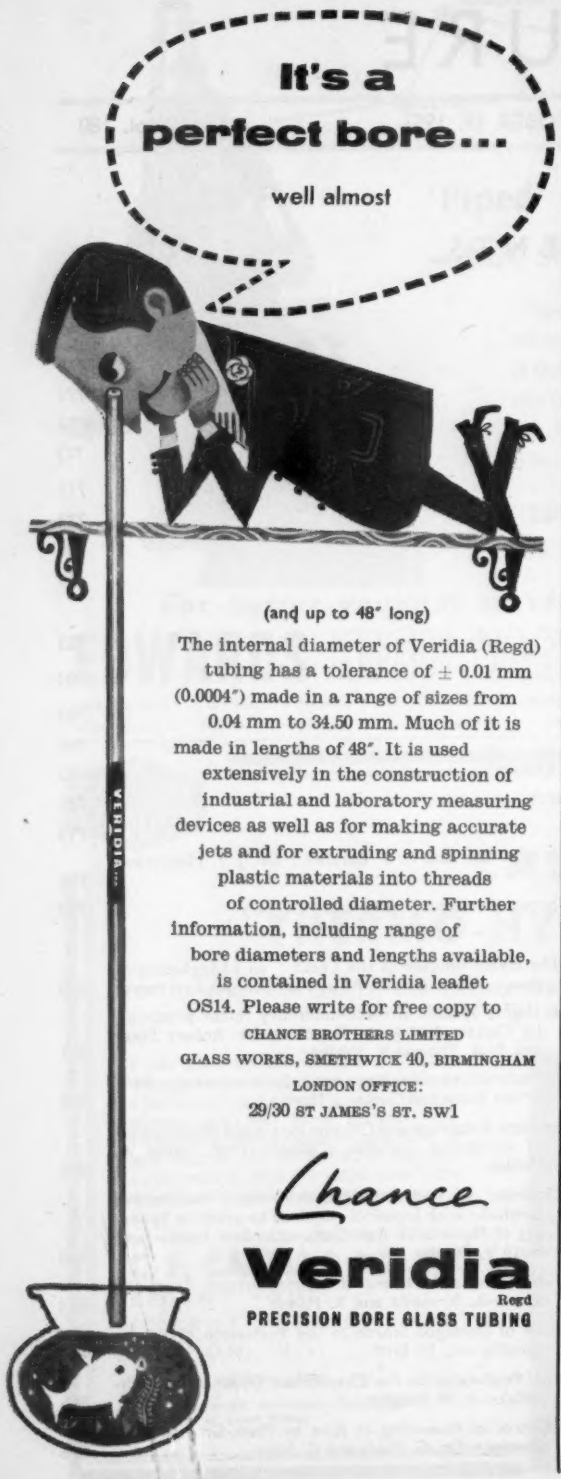

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MUSEUMS AND ART GALLERIES IN BRITAIN

FOR years, and at least since 1939, the Museums Association, representing the museums and art galleries of Great Britain and Northern Ireland, has been urging H.M. Government to take active steps to safeguard such part of our national heritage as is housed in the museums of the country. Perhaps a brief résumé of the past history of this problem will give a clearer picture of the present position and the apparent reluctance of the Government to help in the matter.

It was as far back as 1922 that, at the annual conference of the Museums Association, a resolution was passed urging the Prime Minister to appoint a Royal Commission to investigate and report upon the work of the museums of the United Kingdom. Unfortunately, the death of the fourth Lord Sudeley stopped any progress in this direction, and the Association sought and obtained the good offices and sympathetic interest of the Carnegie United Kingdom Trust. This indeed was a landmark in the history of the museum movement in Britain, for since 1925 to the present day the Trustees and their officers have not ceased to make substantial grants for specific schemes and to explore the possibilities of some permanent form of assistance from the State. In accordance with their general practice, the Trustees commissioned a general report on the museums of the United Kingdom and this was prepared by Sir Henry Miers and Mr. (now Sir) Frank Markham. The report, published in 1928, advocated, among other matters, financial assistance from national funds, government departments, county authorities or other external sources.

Then again, during the presidencies of Sir Mortimer Wheeler and Lord Bledisloe in 1938 and 1939, the Museums Association took active steps to interest the Government in the problem. Lord de la Warr, then President of the Board of Education, promised to set up a Royal Commission on the provincial museum service, but the Second World War intervened.

After the War, the matter was again raised, numerous discussions took place and the most realistic result was the proposal made by the Chancellor of the Exchequer to allocate £250,000 annually for museum purposes. But the economic crisis of 1949 intervened, and the grant did not materialize.

In 1955 the Association renewed its arguments and appointed an influential Joint Committee consisting of representatives of the Carnegie United Kingdom Trust, the Arts Council and itself, to which was later added representatives from the National Institute of Adult Education. The memorandum from this Committee was presented to the Chancellor of the Exchequer on November 16, 1955. The document stressed the rapid growth of the public conscience regarding the value of museums as cultural and educational forces and documented the plight of many of the museums in Britain, especially those in the care of trustees and societies, some of the latter being hard pressed to the point of extinction. It was stated, with convincing examples, that the cost of maintenance, of both the collections and buildings, together with increased salaries and wages of staff, places an increasingly heavy burden on greatly depleted funds. In many cases the struggle cannot continue much longer, and already valuable objects are in dire need of conservation and will be lost to the national heritage unless immediate steps are taken.

The Joint Committee advocated the appointment of a Royal Commission "to inquire fully into the whole question of the financing and administration of all museums and art galleries in the United Kingdom with especial reference to those situated in the provinces". In view, however, of possible delay with a Royal Commission, the Committee urged as a first-aid measure that the Government should make available immediately a fund to help the most necessitous cases. It was recommended that the fund should certainly be not less than £50,000, and to this the Carnegie United Kingdom Trust generously and spontaneously promised a further £25,000. It was further recommended that the fund might be administered simply and effectively by the methods so successfully initiated and maintained by the Joint Committee of the Museums Association and the Carnegie United Kingdom Trust. This Committee could be enlarged by representatives of the Government and any fund allocated with the minimum of expense and without the setting-up of a new organization.

High hopes were entertained that this new approach to the Government would yield positive results; but unfortunately, and just about twelve months after the memorandum was submitted, a negative reply was received to both requests. The Museums Association was told that the problem is essentially a local matter, and that museums and art galleries must look to local authorities for the financial assistance they require; and in denying a Royal Commission the Government stated that the facts are already well known. But despite the reply of the Government, the urgent need for financial assistance exists and several museums must close unless some help is forthcoming. Examples abound and among these may be mentioned the Holburne Museum at Bath and the County Museum in Truro, Cornwall. With excessive economies and existing only by the enthusiasm and self-sacrifice of the trustees and curators, both these institutions have an accumulated annual deficit, and the need for urgent consideration of their problem is self-evident. It was only recently that the trustees of the Bowes Museum at Barnard Castle, where the art treasures have an international reputation, named an actual date for closure.

Fortunately, the Durham County Council came to the rescue and the financial stability of the Museum is assured.

That is the present position of the problem and in spite of the setback produced by the negative attitude of the Government, the Museums Association is discussing the matter actively and bringing forward new proposals. The matter was fully ventilated at a session in the recent annual conference of the Association at Bristol, when under the chairmanship of Sir Mortimer Wheeler the idea of regionalization in museums was discussed. As a matter of broad principle, it is felt that the problem is a national responsibility and not essentially a local matter. The Association stands firm on this, and believes that there should be a central museum authority or commission with local organizations which perhaps could be regarded as regional museums boards.

Although the Government considers that it is fully aware of the facts of the situation, the Joint Committee feels that they are not by any means fully known. It therefore proposes to undertake a complete survey of the museums and art galleries of Britain. Such a survey would be concerned with the geographical distribution of museums and their relationships—chiefly financial—to local and county council authorities. But such a comprehensive survey would naturally be an expensive project, and at present consideration is being given to a pilot scheme probably in the south-west of England. Based on the results of the survey, it should be possible to formulate clearly the function and policy of one of the suggested regional museums boards and to make recommendations regarding its constitution and headquarters.

Even at the present time, the National Museum of Wales carries out some of the functions of the proposed regional museums boards. All museums in Wales and Monmouthshire, providing they attain certain standards, are affiliated to the parent museum at Cardiff. This idea is different from the regional federations in England, where the individual units are loosely held together with no one museum acting as a focus or providing the initiative for any scheme.

In the event of these regional museums boards being appointed, it is felt that the Government would be provided with authoritative bodies through which grants could be made to museums. The reluctance of the Government to make grants to individual museums would thus be overcome by a system of regionalization whereby boards rather than separate museums would be the recipients. It is also visualized that county councils and other local authorities would contribute towards such boards.

But even with such a regional scheme which has been well considered by the Joint Committee, the way still remains open for other means of approach towards the solution of the problem. It may be that the Standing Commission which is appointed by the Treasury could undertake the task and lessen the financial burden of the local museum, and especially trustee or local society institutions. In the terms of reference of this body, provision is made for consideration of the co-ordination of the work of the national museums with those in the provinces. Unfortunately, the Standing Committee has no funds at its disposal, and thus in the past has had no real impact on the museum problem. If, however, its constitution were strengthened and certain monies were available as grants, there is little doubt that such an organization would go far to meet the present unhappy position.

Recently, there has been an undoubted growth of the public conscience concerning the value of museums and art galleries. They are now part and parcel of the normal life of the community, and not something set apart for a few specialists. Museums and art galleries are a definite integral part of the educational and recreational services, and as such should be encouraged and maintained by the Government and not left to the dwindling resources of societies or trustees.

PHYSICS OF THE SOLID STATE

Solid State Physics
Advances in Research and Applications. Edited by Frederick Seitz and David Turnbull. Vol. 1. Pp. xii+469. (1955.) 10 dollars. Vol. 3. Pp. xiv+588. (1956.) 12 dollars.
(New York: Academic Press, Inc.; London: Academic Books, Ltd.)

THE authors of "Solid State Physics" deserve our best thanks—as do the editors, who are continuing to extract review articles of the highest standard covering important branches of physics. Notice of Vol. 2 appeared in *Nature*, **178**, 1139 (1956). Two-thirds of Vol. 1 provides, in effect, a modern handbook on electrons in metals. First there is an excellent expository article by J. R. Reitz, "Methods of the One-electron Theory of Solids", which takes us gently through the basic groundwork and emerges with a detailed and up-to-date account of the 'tight binding' approach (linear combination of atomic orbitals) and the 'cell' method. In addition the author considers a number of more modern developments including the use of orthogonalized plane waves and variational methods. Next comes a remarkable qualitative account of metallic cohesion by E. P. Wigner and F. Seitz. Appropriately enough, the authors base their discussion on the Wigner–Seitz treatment of the cell method; they are specifically concerned with 'difficult' metals—not merely the alkalis.

The next article, "The Quantum Defect Method", by F. S. Ham, is more technical: it describes how, in suitable cases, numerical treatment of the ion-core region in band calculations can be replaced by a knowledge of the atomic spectrum. Many of the ideas here are due to T. S. Kuhn, J. H. Van Vleck and H. Brooks. The last 'metal' article—and that owing least to the 1930's—is an account of electron interaction in metals by D. Pines. It is, of course, based on the collective electron theories due largely to Pines and D. Bohm. This article is very full and readable; it includes some account of relevant experimental data (band-widths, magnetic suscepti-

bilities, characteristic energy losses) and also a section on lattice-electron interaction.

There are two remaining articles in Vol. 1: an account by H. Y. Fan of the properties of germanium and silicon which, although comprehensive, will be found comprehensible by physicists who are not well informed on the subject of semi-conductors; finally, an article on order–disorder transitions in alloys by T. Muto and Y. Takagi which includes a specially valuable discussion of the influence of ordering on electrical, magnetic and mechanical properties.

The subject of order–disorder transitions in alloys is given a more original treatment by L. Guttman in Vol. 3. He makes a serious attempt to judge the Ising model in the light of experiments; the discussion is fascinating and—of course—inconclusive.

There are two stimulating reviews of new subjects in Vol. 3: an account of the unusual semi-conducting properties of Group III–Group V 'intermetallic' compounds by H. Welker and H. Weiss (the electron mobility in InSb is so high that it is possible to use the Hall effect in a small, sensitive device for measuring magnetic fields); and a more theoretical and very elegant article on the continuum theory of lattice defects by J. D. Eshelby.

The masterly survey by C. Kittel and J. K. Galt, "Ferromagnetic Domain Theory", improves and brings up to date a well-known article, now seven years old, by the first author. D. Turnbull writes with his customary authority on the kinetics of phase transitions but is less than happy in other parts of an article entitled "Phase Changes". The remaining contribution to Vol. 3 is a long and turgid, but no doubt expert, treatment of imperfections in crystals by F. A. Kröger and H. J. Vink. It is concerned with their concentrations and uses the methods of physical chemistry.

It is now clear why the quality of "Reviews of Modern Physics" has declined during the past few years: some at least of its potential contributors are giving of their best to collections of the type under notice.

R. O. Davies

EFFECTS OF IONIZING RADIATION

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy

Held in Geneva, 8 August–20 August, 1955. Vol. 7: Nuclear Chemistry and Effects of Irradiation. Pp. x+691. 10 dollars; 70*s*.; 43 Swiss francs. Vol. 11: Biological Effects of Radiation. Pp. viii+402. 8 dollars; 57*s*.; 34 Swiss francs. (New York: United Nations; London: H.M. Stationery Office, 1956.)

VOL. 11 of the Proceedings of the Geneva Conference should be familiar to all those engaged on nuclear research projects where the danger of exposure to radiation is not negligible. In detail it treats with many subjects, in terms not always readily understood by physicists and the like, but there is a sufficient number of general articles extremely well written which will repay careful reading by the non-specialist. Those of us who can remember the conditions of nuclear experimentation, even before the Second World War, in the Cavendish Laboratory will recognize the great improvement which has taken place in our knowledge of radiation hazards and in techniques for their assessment.

Fortunately for the rest of Nature, if we take sufficient care radiobiologically to look after mankind, says Dr. Loutit, Nature will take care of itself, because sensitivity to ionizing radiations is well correlated with the degree of evolutionary complexity (I recall that in another volume the lethal radiation dose for humans was given as 500 röntgen units, for insects 50,000, and for trichinosis 1,000,000). There has been so much experience gained from X-ray and radium damage to human beings that scientists enter the nuclear age reasonably well informed of the general hazards to be faced and, in addition, several Japanese papers give accounts of the first victims of fission.

Apart from radioactive fall-out and war, scientists are only likely to encounter by accident higher doses of radiation than 'permissible', and more evidence is needed about the effects of, and treatment for, doses near to or above 'permissible' levels of radiation. At appreciably lower radiation-levels, profound questions are raised that might not be answered for a long time to come, such as whether radiation, which we know can cause changes in genes, is likely to cause mutations which determine the change from normal to malignant potentiality. It seems that we know virtually nothing about the effects of radiation on the genetics of man, and can only guess what is the dose necessary to double the spontaneous mutation-rate of some genes. An American writer suggests that we might some time arrive at a 'permissible' dose determined by genetic considerations and not merely a dose based on physical injury. As a general precautionary measure the radiation-level of the Thames drinking-water was lowered by a factor of 100, but ultimate figures have not yet been selected, for there is no answer to the question: At what value does the dose-rate assume importance? In spite of these long-term uncertainties, E. Rock Carling's assessment is that in nuclear research establishments where attention is correctly given to radiation dose symmetry, average levels of exposure are far below those recommended as permissible.

L. H. Gray presents a most interesting review of what is known in detail about the biological damage caused by ionizing radiations. At low doses the proportion of cells affected by single ionizing particles increases linearly with the dose. There is no threshold below which the radiation is without effect, and structural damage to chromosomes can be directly observed in strict proportion to the dose, but different cells show differences in sensitivity to radiation. They may all suffer damage, but the injuries in some cells are not manifest. Injury is often made manifest only at the time of cell division, and in the case of seeds this might be years after the date of irradiation. In addition to the physical act of ionization there are the chemical changes which occur even in water, such as the formation of hydroxyl, atomic hydrogen and hydrogen peroxide radicals, and Gray concludes that there are good grounds for believing that the radicals revealed by studies in radiation chemistry play an important part in the development of some forms of radiobiological damage. It is encouraging to turn to later papers by Hollaender and Stapleton, dealing with chemical treatment to prevent or to reduce radiation damage. Certain reducing chemicals will produce effects similar to those obtained when oxygen is absent: some have been found to reduce by a factor of six the damage caused by a given dose of radiation if these chemicals are present at the time

of irradiation, and the properties of radiation protectors suitable for use on a large clinical scale can now, at least, be defined, and work on these seems to be extensive.

The effects of radiation on water is the subject of several papers in Vol. 7, the emphasis here being on water used at ordinary or high pressures, and at low or high temperatures, for the cooling of power reactors, and also on water intimately associated with the fission process as it is in the aqueous homogeneous reactors. Gamma-rays absorbed in water produce mainly the hydrogen and hydroxyl radicals, whereas heavy particle radiation produces molecular hydrogen and hydrogen peroxide. In the presence of intense gamma- and neutron-radiation, as in the Chalk River and other heavy-water reactors, the formation of the hydrogen and hydroxyl radicals is so great that two reverse reactions occur in which the hydrogen ion unites with the hydrogen peroxide molecule and the hydroxyl ion unites with the hydrogen molecule, with the net result that no decomposition of water is observed. This recombination reaction is of comparatively recent discovery, for it was not suspected when water-moderated reactors were first designed. If radicals are removed by some reactive substance, the reaction balance is altered and rapid decomposition of water sets in. In high-pressure water-moderated reactors, control of dissolved gases and acidity of the water are very important, for mass transfer of corrosion products due to temperature or electro-potential gradients can become serious. All the contributors state that the various mechanisms discovered are far from being understood, and a great amount of work yet remains to be done.

A few papers deal with the effect of radiations on liquids other than water, and, in particular, there is the American account of the study of the aromatic hydrocarbons, especially the di- and ter-phenyls under irradiation. These materials are stable up to temperatures of the order of 400° C., but in the presence of radiation form compounds of both higher and lower molecular weight and evolve hydrogen, but in this respect the ter-phenyls show less decomposition than any other substance studied. The conclusion is reached that the stability of these materials is sufficient to justify their use as coolants and moderators in high-temperature reactors operating in the 400° C. range.

Many papers deal with the effect of radiation on solids, primarily on uranium, on moderators such as graphite and beryllium, and on other structural materials used in reactors. The subject is of enormous size and importance and continues to have almost a dominating role in the reactor research and development since Geneva. The damage done to uranium during its life in a reactor is a combination of two phenomena: a change of shape caused by local expansion of the lattice around the fission fragment track, followed by plastic flow on cooling; and an increase in volume due to the accumulation of gaseous fission products, but the damage is especially troublesome because uranium has most unusual crystalline properties. Thorium suffers far less damage but, of course, we are not yet ready to use thorium as a fuel on a large scale. The improvements made to uranium to reduce damage are described in an American paper. Fortunately, the graphite used in reactors is a conglomeration of crystallites, so that radiation damage is not markedly anisotropic: radiation damage to a flake of natural graphite causes expansion one order of magnitude higher than that to artificial conglomerate of graphite. One disturbing report states that damage to graphite in the M.T.R. reactor cannot be correlated with damage to graphite taken from the Hanford reactors. There is very little written about the change of properties of other structural materials used in reactors, but the Russians and Americans who use stainless steel in water- and sodium-cooled reactors give brief accounts.

Vol. 7 deals also with the fission process, and the chemistry of the fission products and the transuranic elements up to curium. It was a pleasure to see Dr. Otto Hahn in the chair at the session on fission process; whereas he discovered barium in the neutron-bombarded uranium in 1938, to-day we know that thirty-six different elements are found and, in all, 300 different isotopes of these elements occur due to fission. He spoke of the safety inherent in the small sources he used, and the papers delivered in that session report the extreme complexity of the modern 'hot' laboratory for handling the fission products.

T. E. Allibone

THE MECHANICS OF THE MIND

Schools of Psychoanalytic Thought

By Dr. Ruth L. Munroe. Pp. xvi+670. (London: Hutchinson Medical Publications, 1957.) 42*s*. net.

IT is a favourite jibe of those who dislike psychoanalysis that it is not a science (or even the beginnings of a science) but another form of religion. Such people disregard the fact that the analyst, remaining almost constantly silent, observes the patient and his thoughts for an hour a day over a period of months or years. Psychoanalysis is based on these observations, and the deductions made from them regarding the deeper levels of the mind. Religion is static except for accretions due to absorbing minor beliefs, but psychoanalysis is daily growing and developing.

This book, which is an excellent one, describes the paths along which the work of Freud is developing. Some of his original views have been modified, and a great deal has been added to his systems.

Dr. Ruth Munroe is a professor of psychology who, moreover, is married to an American psychoanalyst who has contributed a great deal of work on his subject, and lives in an environment with many analytical contacts.

The book is divided into three parts. The first is called "An Overview" and is more or less introductory. The views of the various analysts considered are placed under headings: the terms of the organism, the terms of the milieu, the genetic process, dynamics of the functioning personality, pathology and treatment. This allows the author to compare and criticize the different ideas. The second part of the book considers, from this point of view, the systems of Freud and those who have not deviated too far from him still to retain the term 'Freudians'.

The third part of the book is devoted to Adler, Horney, Fromm and Sullivan. Their investigations and conclusions are put through the same sieve. The fourth section is devoted to Jung and Rank. The last part summarizes the matter which has gone before and collates the whole into a pattern.

It will be seen that such a scheme is a very ambitious one, and it says much for the author's

knowledge, industry, ability and broad sympathies that she has made it not only knowledgeable but readable. She is even capable of reading Jung (who infuriates most analysts) and making his rubrics into something intelligible, although often not acceptable in his terms to those who believe in a different system.

The reader might ask impatiently, what have they found out ? What is all this psychoanalytical investigation about ? Unfortunately without taking up too much space it is difficult to give even an outline. Briefly, the most important discoveries concern the beginnings of thought in the tiny baby. A shaft is being driven into the obscurities of infantile conceptions towards understanding not only how a baby thinks but also why he does so. This gives us clues to the structure and development of the personality. Much of this work is based on the theories of Melanie Klein and her school in England. The work of the other researchers throws a great deal of light on how the person reacts once his personality has matured, and why he behaves as he does. For example, Fromm tries "to relate specific personality types to specific social-economic patterns" and Sullivan shows the importance of the pursuit towards security and so on. The views of others are too well known for comment here.

Anyone interested in psychoanalysis should read this book, which gives a wealth of valuable information only obtainable otherwise by summarizing a large number of original works. Its only fault is that at times it is a little repetitive and verbose, but it is usually extremely clear.

I remember when I was a young man discussing the work of Rutherford and Soddy with a very conservative physicist. The physicist said : "It's all very interesting, but really of no practical importance. We shall never split the atom". Psychoanalysis may be regarded, perhaps, as in a much more primitive state than physics at that time, but it still gives a similar hope for the future. The book is well bound, and excellently printed on non-shiny paper The index and bibliography are adequate.

CLIFFORD ALLEN

CHROMATOGRAPHY—THEORY AND PRACTICE

Chromatography

A Review of Principles and Applications. By Prof. Edgar Lederer and Michael Lederer. Second, completely revised and enlarged edition. Pp. xx+711. (Amsterdam : Elsevier Publishing Company ; London : Cleaver-Hume Press, Ltd. ; Princeton, N.J. : D. Van Nostrand Company, Inc., 1957.) 72*s*.

Fundamentals of Chromatography

By Prof. Harold Gomes Cassidy. (Technique of Organic Chemistry, Vol. 10.) Pp. xvii+447. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1957.) 9.75 dollars.

THE first edition of "Chromatography" by Prof. E. and Dr. M. Lederer was widely accepted as the standard general work on the subject, but the growth of chromatography has continued so rapidly that, after only four years, the authors have considered it necessary to prepare a second edition, which is a complete revision and contains about half as many pages, figures, tables again, and more than 3,700 references—about twice the original number. Some obsolete earlier work has been deleted ; recent developments which previously could only be briefly mentioned, such as gradient elution, radioactive tracer techniques, ion-exchange celluloses for protein chromatography and specific adsorbents, now receive fuller treatment. Gas–liquid chromatography has a chapter to itself which is a short introduction to the subject and an appendix gives the references in this field up to the time of going to press. Many of the original tables are considerably enlarged to incorporate data published in the past few years. Those giving R_F values and solvent systems for paper chromatography of the metals are typical of the thoroughness with which the authors have reviewed applications. Presentation follows a pattern similar to that of the first edition and the result is a very attractive volume. It is perhaps inevitable, in a review of such a vast field, that some topics, such as the paper chromatography of the barbiturates, have been overlooked or treated too briefly, but such examples are remarkably few. It can be confidently predicted that this monograph will be as widely welcomed as its predecessor.

Prof. Cassidy treats the subject from rather a different angle. Although he and the Lederers overlap to a certain extent, their books may be regarded as complementary, since aspects dealt with less fully in one are treated more fully in the other. Thus, the general theory of chromatography and the principles underlying the various types of chromatographic separation, including gas chromatography, are discussed at length by Prof. Cassidy. He also goes very fully into practical aspects and deals in great detail with the use and properties of stationary and mobile phases used in all the forms of chromatography. Guidance to choice of conditions for carrying out chromatograms is among a number of other topics which are discussed fully and a valuable appendix gives sources of equipment.

There are some omissions and inadequacies. In the past few years there have been important developments in the chromatography of proteins, yet this subject is not treated as fully as it deserves. Ion exchange celluloses, for example, are not mentioned, neither is salting-out adsorption nor the use of tricalcium phosphate. There is little about the principles underlying metal separations on ion exchange resins employing complexing agents. On the other hand, too much space is devoted to electron exchange polymers and to foam fractionation. Both methods have so far been little used for separations, and it seems to be stretching definitions rather far to include the second technique as a chromatographic process. However, the chief fault of Prof. Cassidy's book lies with presentation rather than content. A tendency towards garrulity sometimes obscures the points being discussed, as, for example, on p. 198, and there are too many long passages of practically unbroken text which are rather trying to the eye. Added to which the occasional and irritating use of jargon (for example, "overly retarded", p. 377 ; "this is the time analogue of overloading", p. 202 ; "derive patterns of procedure", p. 386) does not make for easy reading. Nevertheless, in spite of these faults, Prof. Cassidy's book is a real contribution to the literature of chromatography since it goes a long way towards improving our understanding of the complex processes taking place in the many varieties of chromatogram.

R. CONSDEN

The Yearbook of the Universities of the Commonwealth, 1957

Pp. lx+2067. (London: Association of Universities of the British Commonwealth, 1957.) 73*s*. 6*d*.

THE aim of the Association of Universities of the British Commonwealth, as the authority responsible for the production of this useful handbook, is that of providing basic information on all the universities and university colleges of the Commonwealth, their activities and their staffs, in a single volume for ease of reference. The present rate of growth, both in number and in size, of the universities in Great Britain, and indeed throughout the Commonwealth, has, however, produced a concurrent expansion in the "Yearbook", which now has more than two thousand pages, compared with less than six hundred in 1921. It has become apparent that the framework of contents and format of the volume could with advantage be altered, the better to accommodate the large increase in information bound between its covers. It is stated in the preface that plans are accordingly now being made for the next issue to appear in a completely revised form, with a different shape and appearance.

Meanwhile, the contents of the present issue have been revised up to May 1956, and in some cases to a rather later date. The University of Leicester still appears among the university colleges, Exeter has taken its place among the English universities, and the entry for the new University of Khartoum—although the Sudan has now no formal connexion with the Commonwealth—is retained in an appendix which also includes the universities of the Republic of Ireland having historical associations with British institutions. Two new Indian universities appear for the first time—Thackersey Women's University of Bombay and Sri Venkateswara University, Tirupati—and a detailed entry is included for the University College of Rhodesia and Nyasaland.

The "Yearbook" remains a source of reference indispensable to all who are concerned with academic, scientific and editorial affairs.

Chemistry in the Service of Man

By Prof. Alexander Findlay. Eighth edition. Pp. xx+326+36 plates. (London and New York: Longmans, Green and Co., Ltd., 1957.) 25*s*. net.

THIS classic was first published in 1916. For the new edition the publishers have used a larger format and have increased the number of illustrations. The 390 pages, each $4\frac{7}{8}$ in. × $6\frac{1}{4}$ in., of the 1947 edition now become 326 pages, each $5\frac{1}{8}$ in. × $8\frac{1}{4}$ in., but in addition there are now twenty-seven line drawings and thirty-six half-tone plates.

Responsive to the shift of emphasis consequent upon the synthesis of many new materials of economic and industrial worth, Prof. A. Findlay has rearranged and rewritten much of the book. He has deleted the old Chapter 2 on atomic structure, and has incorporated the matter in a new Chapter 17 dealing with radioactivity, tracer elements, nuclear chemistry and the right use of nuclear energy. The two chapters on synthetical chemistry, formerly numbered 15 and 16, have undergone much revision and now appear under these new chapter numbers and titles: Chapter 13, "Dyes, Perfumes, Drugs and Insecticides", and Chapter 14, "Artificial Fibres and Plastics". Materials and phenomena in the public eye, such as silicones, Terylene and adsorption, all receive due attention. Forty years ago the publication of this book caused many science teachers to see chemistry in a new light and helped them to promote a better presentation of their subject. Brightened with the new illustrations and everywhere brought up to date, the new edition should delight and inspire a new generation.

Polyesters and their Applications

By the Bjorksten Research Laboratories, Inc. Pp. vii+618. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 80*s*. net.

THIS book reviews the period to June 1954 with a supplement to early 1956. Its principal value is for reference, since more than half consists of an annotated bibliography. Polyesters are defined as the polycondensation products of dicarboxylic acids and dihydric alcohols, thereby excluding polymers with side-chain ester linkages. The introductory theoretical chapter is unsatisfying, brief and in places inaccurate. For example, the molecular weight distribution of the products of a polycondensation is incorrectly stated, and it is surprising to see polystyrene described as a highly polar molecule.

Unsaturated, fibre-forming saturated and di-isocyanate modified polyesters are treated in the next three sections. In places excessive detail is given, as in lists of potential curing agents, whereas the polyurethanes receive only eight pages. Reinforcing fibres are interestingly discussed; the expectation of a good treatment of the sizing and finishing of glass fibres was fulfilled. To regard fibres merely as improving the strength of a resin seems an incorrect emphasis, and a discussion of fibre orientation is lacking. The chemical reactivity of glass fibres is greater than might be inferred by the reader of this section.

The reproduction of data sheets and the discussion of specifications other than those of the well-known American Society for Testing Materials and Federal series remind British readers of the source and principal users of this book. A brief chapter on health hazards should fulfil a useful purpose.

E. W. Russell

Soil Physics

By Dr. L. D. Baver. Third edition. Pp. xvii+489. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 62*s*. net.

"SOIL PHYSICS" was originally designed as a text-book for graduate students in agronomy, but over the years it has become something more. Advisory and research workers, including professional physicists, have used it as a standard reference book, and, perhaps somewhat unfairly, have criticized it because the treatment of many topics was not thorough enough to meet their specialized needs. The new edition will silence some of, but not all, this criticism, for it is more nearly a book about physics than either of the first two. It has all their virtues in an enhanced form, with new chapters on irrigation and drainage, and new material on several aspects of soil structure and stability. The outlook remains essentially practical, the descriptive sections are well written, there are plenty of tables and diagrams of field observations, and as all this is supported by an excellent bibliography, Baver's "Soil Physics" will have no difficulty in holding its place as the best available general guide to the physics and physical chemistry of the soil.

ROYAL AIRCRAFT ESTABLISHMENT, BEDFORD

By L. H. G. STERNE
Chief Superintendent

A NEW aeronautical laboratory was formally opened at Bedford by Mr. Aubrey Jones, the Minister of Supply, on June 27. This laboratory, which is part of the Royal Aircraft Establishment, was planned during the closing years of the Second World War when it was evident that there was inadequate space in the Establishment's Farnborough laboratory, either for the runways required for flight research on supersonic aircraft, or for the considerable variety of wind tunnels which alone can provide the aerodynamic knowledge essential to the successful design of aircraft and missiles.

By mid-1946 plans for both the wind-tunnel site and the airfield at Bedford were well advanced, and at the end of 1949 most of the roadways had been completed and work had begun on a 3 ft. × 3 ft. supersonic wind tunnel. Three years later this tunnel was in full operation, assisting the aircraft industry in testing models of new designs, and a good deal of work had been done on the construction of the main runway. Further tunnels have since been constructed, notably the recently completed 8 ft. × 8 ft. —the most powerful and complex wind tunnel in Britain. The Naval Air Department and the Flight Division of the Aerodynamics Department were transferred from Farnborough to Bedford Airfield in 1955 and the Blind Landing Experimental Unit joined them from Martlesham Heath this year.

Wind tunnels. The wind tunnels at Bedford are intended to be complementary to those at Farnborough and the work done in them is part of an integrated programme of aerodynamic research pursued by the Royal Aircraft Establishment as a whole. When the 4 ft. × 3 ft. tunnel (now under construction) is completed, the Establishment will be equipped with an extremely valuable range of wind tunnels in which models of useful size can be tested from low speeds, through the speed of sound, up to a Mach number of 5.

Two main kinds of work are done : first, tests are made on models of actual aircraft or missiles, either to measure their characteristics before they have flown, or to investigate the cause and cure of troubles which have been encountered in flight ; and, secondly, tests are made on idealized shapes, either to check theoretical calculations, or to obtain basic aerodynamic information to assist future design.

Except in the vertical spinning tunnel, the basic method of testing is the same in all cases : the model is supported in the airstream and measurements are made of the forces acting on the model, or of the pressure and velocity distribution on the model surface or in its wake. In order to save time, both in the testing and the subsequent analysis of the results, arrangements are provided for recording all measurements automatically : by curve plotters to provide a visible record immediately, and on punched cards for later reduction by an electronic computer. In addition to these measurements, various methods of flow visualization are used ; for example, oil films, smoke trails, and optical schlieren equipment. All the tunnels at Bedford are of the continuous-flow type.

Fig. 1. Photograph of smoke trails taken in the 13 ft. × 9 ft. wind tunnel showing vortex pattern behind a delta-shaped wing

The 13 ft. × 9 ft. subsonic wind tunnel has a speed range from zero to 300 ft./sec. and is mainly used to explore the low-speed (including take-off and landing) characteristics of aircraft and aerodynamic shapes designed for good performance at transonic and supersonic speeds (see Fig. 1).

The tunnel circuit is constructed mainly in concrete, and the air is circulated by a single-stage fan, 30 ft. in diameter, driven by a 1,500 h.p. direct-current electric motor, with a Ward–Leonard control. To ensure an exceptionally high degree of uniformity of flow in the working section, there is a large settling chamber giving a contraction ratio of 16 : 1, fitted with four fine-gauze screens. Auxiliary compressor and evacuator plant is provided for tests involving boundary-layer control by sucking or blowing.

The 3 ft. × 3 ft. supersonic wind tunnel can be operated at any supersonic speed up to a Mach number of 2, variation of speed being effected by the use of interchangeable shaped-blocks on one of the walls of the working section. An alternative working section of the ventilated type is also available, enabling tests to be made at transonic speeds (see Fig. 2). This tunnel can be operated at any stagnation pressure between 0·1 and 2 atmospheres absolute, and is powered by electric motors totalling 16,000 h.p. driving two centrifugal compressors in series.

The 8 ft. × 8 ft. supersonic wind tunnel (Fig. 3) is the largest of its kind in Britain. It can be operated at any Mach number from zero to 2·8 (excluding the transonic range) and the stagnation pressure can be adjusted to any value in the range 0·1–4 atmospheres absolute. It is driven by electric motors totalling 80,000 h.p., and the electricity supply can be obtained

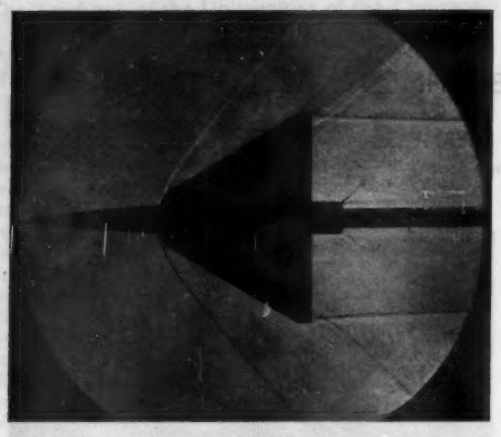

Fig. 2. Shock-wave pattern; picture taken in 3 ft. × 3 ft. supersonic wind tunnel

either from the National Grid or from a gas-turbine generating station on the site, the latter source being limited to about 50,000 h.p. A feature of this tunnel is the adjustable nozzle (for varying the Mach number in the test section), consisting of two flexible steel plates 62 ft. long and 1 in. thick, bent to the required shape by hydraulically operated jacks which are set to a high degree of accuracy by an elaborate control system. The supersonic diffuser following the working section is also made adjustable, to reduce the power required to drive the tunnel.

The 4 ft. × 3 ft. supersonic wind tunnel, which is still under construction, will have a Mach number range from 2·5–5, and will work at pressures up to 15 atmospheres absolute. Its power will be 88,000 h.p., and, as in the case of the 8 ft. × 8 ft. tunnel, the electricity supply can be taken either from the National Grid or from the gas-turbine station. Flexible steel walls will be used for providing variation of speed in the working section.

A special feature of this tunnel is that provision is being made for operating at stagnation temperatures up to 150° C., in order to avoid partial liquefaction of the air in the working section at the higher Mach numbers.

The vertical spinning tunnel is used primarily to observe the behaviour of free models in spinning flight, and particularly to investigate methods of recovery from a spin. The working section is 15 ft. in diameter, and the air flow, which is directed upwards, is under the direct control of the operator, so that the model remains at the same height and can be kept under observation all the time.

Pressure in the tunnel can be raised to 4 atmospheres absolute to reduce scale effect, and the maximum air speed is 90 ft./sec. at full pressure and 140 ft./sec. at atmospheric pressure. The air is circulated by a variable-pitch fan, driven by a synchronous motor of a nominal 1,500 h.p. with an overload capacity of 3,000 h.p.

Airfield. Bedford Airfield is surrounded by open countryside, affording excellent approaches to all runways, and is especially suitable for research on high-speed aircraft. The main runway is one of the longest and widest in the country (10,500 ft. × 300 ft.). There are two other normal-flying runways, and, in addition, the Naval runway fitted with carrier-type arrester gears for research into the recovery of naval aircraft. The control tower is equipped with the latest types of radar equipment giving a coverage of 100 miles with full talk-down facilities of the latest type. There is a two-channel, multi-frequency, cathode-ray direction finder, and

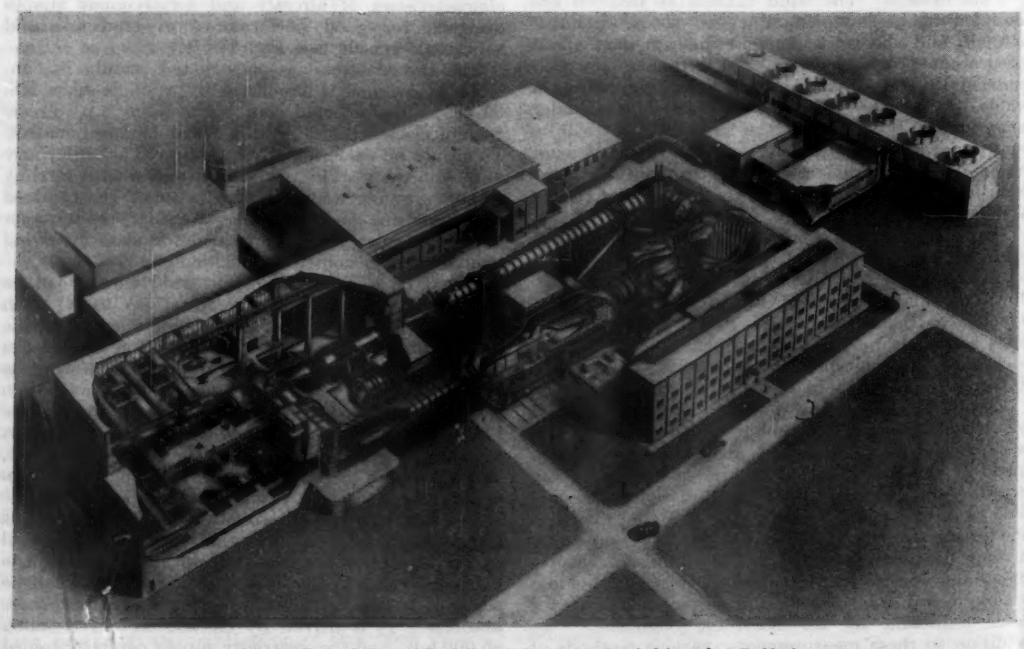

Fig. 3. General view of the 8 ft. × 8 ft. supersonic wind tunnel at Bedford

the airfield is an integral part of the Establishment's very-high-frequency fixer network, with which it is possible to cover most of the country.

Aerodynamic flight research. The underlying aim of the work of the Flight Division of the Aerodynamics Department is to further the improvements of future aircraft, either directly, by determining the value of aerodynamic innovations in design, or indirectly, by the introduction of new or improved test techniques or means of recording and processing data from flight tests.

The research problems considered by the Division include those associated with low-speed flight, particularly landing and take-off, as well as performance, stability and control at transonic and supersonic speeds. The aircraft used in this work fall into three categories: aircraft which differ from standard only by the inclusion of special test instrumentation (for example, a Hunter aircraft instrumented to measure tail-loads); standard aircraft modified by the incorporation of special devices and intended mainly as test vehicles (for example, the Meteor aircraft with jet deflexion); and aircraft designed and built specifically for research purposes (for example, the Rolls-Royce 'Bedstead' and Short *S.C.*1 designed to study the stability and control problems of vertical take-off and landing, and transition to normal flight).

The 'flight simulator', now under construction, is basically an analogue computer capable of solving continuously the equations of motion of an aircraft under various conditions of flight, and presenting this information both as records on paper, and as a visual display similar to that experienced by the pilot in flight. It can be used for studying the behaviour of a projected design and the pilot's reaction to it, under a wide range of conditions.

Naval Air Department. The Royal Navy has its own special problems arising from the requirement that its aircraft shall operate from carriers. While naval aircraft, in common with all military aircraft, have steadily increased in weight, size and speed, there can be no comparable increase in the size of the ships from which they operate. Thus there is a continuous and exacting problem of maintaining compatibility between the carrier and its aircraft. Important items of research on naval aircraft include the development of devices such as boundary-layer control to reduce take-off and landing speeds and the development of a technique for assessing the view from an aircraft cockpit at various angles of incidence during the approach phase.

The greater part of the Royal Aircraft Establishment's flight research work on helicopters is centred in the Naval Air Department. In addition to the problems of operating from moving ships, studies are made of the problems of stability and control, with particular reference to all-weather flying in civil and military operations.

The major experimental facilities of the department include a 200-ft. stroke, steam-powered, slotted-tube catapult. This is set in a deck some 5 ft. above ground-level, so that aircraft can be launched into space as off the bows of a carrier. The main purpose of this catapult is to 'proof' aircraft and to investigate launching techniques and phenomena. A second and similar catapult is being installed at ground-level to investigate the problems of using much higher steam pressures to obtain a greater level of energy. This second catapult will be used for launching both aircraft and dead weights, the latter being essential during the development stage of the catapult itself.

Typical aircraft-arresting gears are located in a vault below the Naval runway, thus reproducing the layout adopted in an aircraft carrier. The arresting wires, two from each gear, are stretched across the runway, as across the flight deck of a ship, and are provided primarily for 'proofing' aircraft.

The third major test facility is the safety-barrier and arrester-gear proving base. Here a deadweight trolley (representing the mass of an aircraft) is launched by means of a cordite-powered, slotted-tube catapult into an arresting wire in the process of developing arrester gears; or the conventional arresting wire may be replaced by a safety barrier net and aircraft launched into it at representative landing speeds.

Various instruments are under development in the department to facilitate operational efficiency and assist research and development. Among these are the deck-landing mirror sight which, in its present stage of development, is already a standard fitting to carriers of the Royal and United States Navies.

Blind Landing Experimental Unit. The Blind Landing Experimental Unit is, as its name implies, engaged upon the research and development of aids to enable aircraft, whether military or civil, to land at an intended destination, irrespective of weather conditions. Despite significant improvements in bad-weather aids over recent years, low-cloud base and reduced visibility still impose a very serious limitation on present-day aviation, dislocating alike the operational plans of military aircraft and the regularity and efficiency of civil airlines. Safe and successful landing in all weathers remains one of the most outstanding problems confronting aeronautical scientists and engineers to-day.

The intention is to install on the main runway the most modern aids for the landing of aircraft in all weathers, to be used not only for further experiments but also as an example of the equipments available and their performance, and to provide a model 'instrument runway'.

In common with most remote-control systems, the development of blind-approach and landing aids falls logically into two parts: the radio guidance system, which must provide steering information for the aircraft relative to an ideal path in space irrespective of weather, and the control system, which accepts the steering information and manœuvres the aircraft to a safe position for landing. The Unit employs experts in radio and automatic-control technique, and an assessment group which examines the operational success of the various aids in service and under development.

An approach and landing simulator is used for studying, on the ground, the problems of the transition from instrument flight to visual flight, examining, for example, the effects of forward speed, downward view and changes in aircraft flying characteristics.

Equipment is currently available which allows approaches to be made with an automatic pilot flying the aircraft down a radio beam to a height of about 150 ft. above the ground, the pilot needing only to take over the final landing, using the approach lighting pattern for visual guidance. The present programme is aimed at eliminating this final visual phase of the landing and devising techniques for landing completely blind.

EXPLORATION OF THE DEEP OCEAN FLOOR

FOUR widely different aspects of deep ocean exploration were discussed at a session of Section A (Mathematics and Physics) of the British Association for the Advancement of Science during its recent meeting at Dublin. The discussion was held on September 10, with the president of the Section, Prof. T. G. Cowling, in the chair. The methods of exploration that were described included seismic refraction shooting, underwater photography, the analysis of magnetic spherules found in deep-sea sediment and, finally, the examination of the oceans from manned bathyscaphs.

The seismic method of exploration was described by Mr. R. D. Adams, of the Department of Geodesy and Geophysics, University of Cambridge. An explosive charge is fired in the sea, and the resulting sound waves travel out through the various layers of rock beneath the sea-floor. By measuring the time taken for the sound waves refracted through these rock layers to reach receivers at distances of several miles from the explosion, the thicknesses of the various layers may be determined, together with the velocities of sound in them. By comparing these velocities with those measured in rocks of known geological composition, an idea can be formed of the type of rock that underlies the oceans.

Mr. Adams then described the typical structure found under deep ocean basins. In these areas the depth of water is generally between four and five kilometres. At the floor of the ocean we find a layer of loosely packed sediment which may be as much as one kilometre thick. Beneath this is a layer of more solid rock, which may be a consolidated sediment or perhaps volcanic lavas. This layer is one to two kilometres thick and overlies a further layer of what is probably a basaltic igneous rock. Finally, at a depth of approximately eleven kilometres under the surface of the sea, and six kilometres under its floor, rock is encountered for which the velocity of sound is the same as that observed at a depth of some thirty kilometres under the continents. This discontinuity of velocity is taken to mark the boundary between the Earth's crust and its mantle. Thus, the seismic method of exploration gives us an idea of the structure of the sub-oceanic crust, and shows that this crust is considerably thinner than that under the continents.

Magnetic measurements may also be used for exploring submarine structure. Mr. Adams spoke briefly of the nuclear spin or 'proton' magnetometer that was used at sea during the 1956 summer cruise of R.R.S. *Discovery II* (see *Nature*, 180, 10; 1957). Protons in a sample of water behave as small spinning magnets, and can be made to precess about the direction of the Earth's magnetic field. The frequency with which they do this is directly proportional to the strength of the field; hence by measuring this precession frequency the strength of the Earth's magnetic field may be easily and accurately determined. In this way, magnetic anomalies related to submarine structure may be traced.

The next speaker was Dr. A. S. Laughton, of the National Institute of Oceanography, who described the exploration of the ocean floor by echo-sounder and underwater camera. He explained how the development of the acoustic echo-sounder had enabled continuous profiles of the depth to the sea floor to be obtained, instead of the isolated wire soundings that previously had been the only indication of depth. From these soundings it is found that once the edge of the continental shelf is passed, there exist vast abyssal plains which are flat to one part in one thousand over distances of several hundred miles. By contrast, regions of extreme ruggedness have been mapped, and there are also areas of an intermediate type of topography. Large canyons are also found, which Dr. Laughton suggested might be due to turbidity currents. These are turbulent suspensions of sediment in water, which are capable of cutting through the continental shelf.

Dr. Laughton then showed a series of photographs of the ocean bottom, taken with the underwater camera which he has developed. The camera is lowered into the sea on a framework which also supports a light source and an acoustic device for transmitting a sound signal back to the surface every time a picture is taken. The camera is triggered when a weight hanging beneath it strikes the sea floor. The operator at the surface then hears the sound pulse, and raises the camera a few fathoms before lowering it again to take the next picture.

The first photographs shown were of a relatively smooth ocean bottom at a depth of 2,600 fathoms. Tracks of small animals were seen in the bottom sediment. A most interesting series of photographs was taken in water of decreasing depth while the ship drifted over a seamount to the north of Madeira. Loose boulders, areas of sediment, and outcrops of rock were visible at various depths. Some indications of bottom life were observed at all depths, but these became more abundant as the depth decreased. In the photograph reproduced herewith (Fig. 1), the level bottom of globigerina ooze shown is typical of large areas of the floor of the ocean basins. The mounds, which are up to a foot in diameter, result from the burrowing activities of bottom-living animals. To the left is a track, outlined by 'foot-prints' made, possibly, by a holothurian. Finally, Dr. Laughton showed three colour slides of the bottom, which revealed an unexpected variety of colour, especially red.

The next paper was by Messrs. A. A. Smales and D. Mapper, of the Analytical Chemistry Group, Atomic Energy Research Establishment, Harwell. Mr. Mapper read the paper, which was entitled "Neutron Activation Analysis of 'Cosmic' Spherules from Marine Sediment". He described a collection of magnetic spherules, of mean diameter 44 microns, which have been found in deep-sea sediment. Spherules of similar appearance have been collected from the atmosphere, and the aim of this work was to carry out a chemical analysis of spherules collected from different sources, for comparison among themselves and with material of known meteoric origin.

The amount of material available for this analysis is extremely small; in some cases the total weight of a sample is only ten micrograms. The analysis of such small amounts of material by conventional chemical means would be extremely difficult.

Fig. 1. [Photograph by Dr. A. S. Laughton taken at station 3461.1, position 36° 36′ N., 17° 13′ W., depth 4,670 metres. Area of picture 3 m. × 5 m.

The method of neutron activation consists of bombarding the specimen with slow neutrons in a nuclear reactor, thus inducing certain elements to form radioactive isotopes. After irradiation the sample is dissolved in a solution containing comparatively large amounts of the stable isotopes of the elements which are sought in the analysis. These act as carriers for the radioactive isotopes, and after thorough mixing a chemical separation is effected in which the radioactive isotopes from the sample remain with their carrier elements. The total amount of radioactivity found in each element is independent of the amount of carrier used, and enables the amount of this element contained in the original sample to be calculated. This method is free of the contamination difficulties associated with the conventional methods of chemical analysis of small samples. In practice, the amount of each element present in the sample is determined by using a standard specimen containing a known amount of the element, and comparing the activities of sample and standard after both have been subjected to the same amount of radiation. The sensitivity of the method is such that quantities as small as 10^{-12} gm. of certain elements can be detected. For cobalt and copper the minimum detectable quantities are 6×10^{-12} and 6×10^{-11} gm., respectively.

By this method samples of four types of spherules were analysed for nickel, cobalt and copper. The neutron activation method is unsuitable for the detection of iron, so the iron content was determined colorimetrically using a spectrophotometer. The four samples were: (1) spherules extracted from deep-sea sediment cores collected in the Pacific Ocean; (2) spherules extracted from a manganese nodule found in one of the cores; (3) spherules extracted from rainwater collected on the coast of Sweden; (4) spherules extracted from sand in the River Danube near Vienna.

The composition of meteoric material can be determined in the laboratory, and it is found that iron, nickel and cobalt constitute 99 per cent of iron meteorites. The ratio of the amounts of nickel to copper, nickel to cobalt, copper to cobalt and nickel to iron found in these iron meteorites was compared with the values of these ratios found in the four types of spherules. A definite similarity was found between these ratios for the iron meteorites and the spherules of marine origin. The spherules collected from rainwater and from the Danube, however, show no chemical similarity to the meteoric matter.

The dangers of ascribing a cosmic origin to spherules collected on land must not be overlooked. It appears that these particles may be industrial by-products carried in the atmosphere. There is, however, no chemical objection to attributing a cosmic origin to those spherules discovered in deep-sea sediment.

In the final paper, Dr. Robert S. Dietz, of the U.S. Office of Naval Research, Washington, described a descent that he had made in the bathyscaph *Trieste* to a depth of 1,100 metres near the Isle of Capri. Owing to indisposition, Dr. Dietz was unable to present his paper himself, and it was read by Commander Dean Farnsworth.

This method exploring the deep ocean bottom is the most personal that has yet been used. Dr. Dietz stressed the value of being able to see the bottom, rather than having to rely on the evidence of single

photographs or the movement of television cameras. He briefly described the bathyscaph, for the construction of which M. Jacques Piccard was largely responsible. The craft is similar in principle to the lighter-than-air balloons designed by M. Piccard's father. The buoyancy is obtained by using a float filled with petrol, and, by adjusting ballast and releasing small quantities of petrol, the trim of the craft may be altered so that it will ascend or descend at the will of the operator. Below the float is a cabin, two metres in diameter, which will hold two men. Two conical windows of 'Perspex' permit observation from the cabin.

The depth of 1,100 metres is the greatest that is available in the neighbourhood of Capri, from where the bathyscaph is now operating. The cabin is designed to withstand a pressure equivalent to 6,000 metres of water, and as the petrol compartment of the float is open to the water, this is not affected by changes of pressure. There is thus no reason why the craft should not be able to descend to all but the deepest oceanic areas.

Dr. Dietz described in some detail the descent he had made. The dive lasted two and a half hours and included about forty-five minutes on the bottom. Some light was visible down to a depth of 525 metres. At greater depths than this, floodlights were switched on intermittently. Some scattering particles, presumed to be zooplankton, were observed at all depths, but the maximum amount of life was found between 500 and 700 metres. The sea bottom appeared to be composed of soft brown mud, and there was little evidence of bottom life. Three small fish were seen near the bottom, however, and some mounds and burrows similar to those photographed by Dr. Laughton were observed. During the more rapid ascent, which took only forty minutes, a turbulent eddy of water travelling with the bathyscaph made observation difficult.

In the short discussion which followed the papers, Prof. T. G. Cowling asked Dr. Laughton whether the flat areas of sediment found on some parts of the ocean floor would cover a buried topography of the basement rocks. Dr. Laughton replied that this was almost certainly the case.

Dr. B. J. Mason remarked that he was not surprised to learn that magnetic spherules of industrial origin were transported large distances from the areas where they were liberated into the atmosphere. In his work he had had experience of salt particles from the sea being carried several hundred miles inland.

R. D. Adams

POWER FROM NUCLEAR FUSION

A SESSION of Section A (Physics) of the British Association was held in Dublin on September 6 under the prophetic title: "The Industrial Applications of Thermonuclear Reactions". This was under the chairmanship of Prof. T. G. Cowling, and followed his presidential address on "Stellar Energy and Stellar Evolution", which had included a discussion of thermonuclear reactions in the stars.

Two papers were read; the first, by J. D. Lawson (U.K. Atomic Energy Authority, Harwell), consisted of a brief review of the basic physics of the reaction process and the properties of the hot gas. The second, by Sir George Thomson, dealt more specifically with the problem of containing the hot gas out of contact with the relatively cool walls of its container. After the papers there was a brief but animated discussion.

Mr. Lawson said that if an efficient method could be found of burning to helium the deuterium which occurs in water then the world's fuel problem would be solved virtually for all time. Fusion reactions between ordinary light hydrogen nuclei (protons) are important in the stars, but would be almost undetectable in any conceivable terrestrial system; reactions employing the heavy hydrogen isotopes, deuterium and tritium, on the other hand, are about 10^{25} times more probable. A mixture of deuterium and tritium is by far the most 'inflammable' fuel; unfortunately, however, tritium does not occur naturally. It can nevertheless be bred by capturing the neutrons emitted during fusion in the light isotope of lithium, which decays into tritium and helium. Lithium is not a common metal (reserves are probably comparable with those of uranium), and the ultimate aim must be to use a cycle based on deuterium. The rate of reaction for this cycle is about one hundred times less than that for the tritium/deuterium cycle, and the problem of making a power-producing system is considerably more difficult.

Temperatures of a few million degrees are required for fusion reactions to be detected, but for appreciable power to be produced at least a hundred million degrees is necessary. At such temperatures the gas is completely ionized. Radiation is in the form of bremsstrahlung (or 'free–free' electron transitions); its intensity increases as the square root of the temperature, and is proportional to the volume of the gas and the square of the density. This departure from the behaviour of a 'black body' is due to the fact that the range of the photons in the gas is very large compared with the linear dimensions of the system, so that the gas is almost transparent. Now the rate of reaction is also proportional to the volume and the square of the density, and hence the ratio of reaction power to radiated power is a function of temperature only. The two are equal at the 'critical temperature', which is about 150 million deg. for deuterium and 30 million deg. for a tritium/deuterium mixture.

It does not follow, however, that if a mass of fuel is heated to the critical temperature it can be 'set off', as in chemical explosion or combustion. The reason for this illustrates another difference between terrestrial and celestial systems; the ranges of the reaction products are very long, so that the neutrons are bound to escape from the gas without imparting their energy to it, though the charged reaction products can in principle be retained by means of suitable electric or magnetic fields.

The discussion so far illustrates some of the basic features of the reaction process, and indicates the difference in scale between a fusion reactor on one hand, where mean free paths are long compared with the linear dimensions of the system, and stars on the other hand, where the mean free paths are relatively short.

The central problem, however, is not that of producing a hot gas, difficult though this is, but of

devising a system which produces more power than it consumes. A fission system needs no power to prime it, since, once a suitable lattice of fuel and moderator is assembled, heat appears. In a fusion system, on the other hand, electrical energy is required to heat the gas and to provide external magnetic fields. It is no use, for example, making a system which consumes one megawatt of electricity and only produces a further megawatt of heat, since some three megawatts of heat are required in the first place to produce one megawatt of electricity. Conditions for a favourable power balance are very stringent indeed; the gas must be heated above the critical temperature in almost complete isolation from the walls for long enough for at least a few per cent of the nuclei to be burnt.

Mr. Lawson ended by saying that the problems still to be solved appear at the moment to be formidable, and that it is not yet clear which road, if any, will lead to success.

Sir George Thomson then spoke on the problem of containing the hot gas. He started by saying that it takes a great deal of energy to heat the gas to the required temperature of 10^8–10^9 deg., and that this heat must not be allowed to escape until a substantial fraction of the gas has been burnt. For the densities likely to be used, say, 10^{16} particles/cm.^{3}, deuterium must be contained for about a second if a net power yield is to be obtained.

A gas in the completely ionized state which occurs at these temperatures is known as a 'plasma'; the mean free paths of the particles are very great, and the electrical conductivity may exceed that of copper at room temperature. In consequence of this high mean free path one cannot hope to keep the gas together by the entanglement with each other of the particle motions; an attempt to use this method would result either in a bomb, or in a system of quite impractical size.

Now heat can be lost by radiation, conduction and convection. Radiation losses are serious, but acceptable; this is fortunate since there seems to be no way of preventing them. Loss by conduction, on the other hand, would be prohibitive if nothing were done to prevent it. Sir George then did a simple calculation to show that, for a density of 10^{16} particles/cm.^{3} and a temperature of 10^8 deg., loss of heat by conduction from a sphere would exceed that by radiation unless the radius were greater than 100 km.

At first sight, one might hope to gain by departing from a Maxwell–Boltzmann gas. This is not possible, however, since the scattering cross-section greatly exceeds that for the nuclear reaction in deuterium, and consequently the ions will achieve a fair approximation to equilibrium if the high temperature is sustained long enough for a substantial fraction of them to react. In these circumstances Boltzmann's relation between potential energy and density will hold roughly, and this shows that if the density at the edge is to be really small compared with that at the centre there must be a potential difference between these which is at least a substantial multiple of kT/e, where k is Boltzmann's constant.

This shows that containment is ultimately by electric fields, though this fact may be well concealed. Containment by electrostatic fields applied externally is indeed impossible, but large internal electric fields can arise from a very small separation of positive and negative charges. A field so directed as to stop positive ions from striking the walls will impel electrons to do so; this must be stopped, and it is hoped to achieve this by anchoring the electrons by means of a magnetic field. Electron orbits in the presence of a magnetic field are 'coiled up' and the rate of diffusion is greatly reduced. If, however, an electric field is also present the particles move in trochoidal orbits, in an average direction perpendicular to both the electric and magnetic fields. Scattering does indeed result in a gradual shift of the orbits, which are pushed downhill, so to speak, by the electric field, but when the magnetic field is strong this process is very slow. The steady state predicted by the Boltzmann expression will not in practice even be approached by the electrons.

A full analysis of the behaviour of the plasma under the action of both electric and magnetic fields would be very complicated. However, in the special case of the steady state where the conductivity of the plasma is high, the relatively simple result is obtained that a current at right angles to the magnetic field will cause a gradient of pressure perpendicular to both and equal (in suitable units) to their product. The current is roughly what it would be if there were no magnetic field. It remains to adjust this gradient of pressure so as to keep the gas away from the walls of the vessel. One way of doing this is to use the 'pinch effect', which occurs when a heavy current is passed through a gas contained in a cylindrical vessel. The current elements attract one another, and a narrow current-channel forms away from the walls of the cylinder. Another way of looking at this is to regard the lines of force due to the current, which form rings round it, as possessing a tension equal to $H^2/8\pi$ (where H is the magnetic field).

The drawback of this arrangement is that the current-channel is unstable. If for any reason it bends, the magnetic lines become crowded together inside the bend; this increases the magnetic pressure there and the bend is accentuated. It is not easy to avoid this, which may be an outstanding difficulty.

Another method is to use a magnetic field produced externally which might, for example, be arranged to go tyrewise round a torus. The setting up of such a field will produce currents in the gas, this time round the cross-section of the torus. Such currents have a magnetic field which tends to neutralize the applied field inside them, and the gas at the centre is held in by the sideways pressure of the tyrewise lines of force, which is still strong in the outer parts of the cross-section. Here again instabilities are troublesome, although it seems that a combination of the two sets of currents may have possibilities.

The third form of heat-loss, by convection, is essentially associated with turbulent motion, and does not occur in a steady state such as one might hope to obtain in a heated plasma. Where instabilities occur, however, as in a pinched discharge, one would expect large losses of a convective character due to masses of gas being thrown against the walls. This is one reason why instabilities are undesirable.

Finally, how can energy be extracted from the hot gas? The heat transferred through the walls of the containing vessel could be used for raising steam, but a more attractive possibility is to make use of the magnetic properties of the plasma to induce electrical power directly in some external coupled circuit. It is not yet clear how this could be done, but the possibility exists.

Sir George ended by saying that he had sufficient confidence in the ingenuity of electrical engineers to believe that, since no fundamental reason had been found in ten years which made a fusion reactor impossible, this amounted to proof that it could be made.

Among the topics raised in the discussion after the talks was the possibility of using thermonuclear neutrons for breeding fissile material, and the point was made that this might be worth while even if the thermonuclear reaction cycle itself was not self-sustaining. It is, however, too early yet to say how this would compete with 'conventional' breeder systems.

Asked whether power might be achieved using the 'cold fusion' process, whereby the hydrogen and deuterium nuclei in a mesic molecule coalesce and fling out the meson with high energy, Mr. Lawson said that it was unlikely that a meson, sufficiently long lived to make such a process economical, existed. It was agreed, however, that this was a very interesting phenomenon, and showed that quite unexpected things may still happen.

The discussion was not entirely satisfactory, however, since some of the most interesting questions could not be answered for reasons of security. There is no doubt that Prof. Cowling echoed the feelings of the meeting when he said, in thanking the speakers, that he looked forward to the day when it would not be necessary to answer questions by referring only to the latest *published* information.

J. D. Lawson

THE DEFENCE RESEARCH BOARD, CANADA

By C. A. POPE

THE Defence Research Board, Canada's largest scientific organization, celebrated its tenth anniversary recently.

During the later stages of the Second World War, the efforts of Canadian scientists indicated that research could provide vitally important support to the Armed Forces; and the desire of the National Research Council and other scientists involved to return to civilian research pursuits made obvious the creation of a permanent defence research organization. Hence was born the Defence Research Board on April 1, 1947. The first chairman was Dr. Omond M. Solandt, a youthful, war-time operational research scientist, who was succeeded in March 1956 by Dr. A. Hartley Zimmerman, previously a member of the Defence Research Board and vice-chairman of the organization for about a year.

The Board is believed to be unique as a scientific body because it is directed by civilians although integrated within the Department of National Defence, and it has surmounted successfully a series of growing pains and has achieved international recognition for its efforts on behalf of defence research.

Among the problems overcome during the first ten years of the Board's existence were the initial phase of organization, the establishment of a carefully planned scientific programme—interrupted by urgent Korean War requirements—and a widespread re-organization following the end of hostilities with emphasis on new and increasingly important military fields.

The keystone of defence science in Canada is the Defence Research Board itself, which consists at present of fourteen members, six of whom are *ex-officio* and six of whom represent Canadian science both from the universities and from industry. The chairman and vice-chairman are permanent, salaried members of the Board. The chairman is appointed by the Governor-General-in-Council; his status is that of a chief of staff and, as such, he sits on the Chiefs of Staff Committee. He possesses many of the financial and other powers of a deputy minister, since he reports directly to the Minister of National Defence.

The Board operates with three main objectives in mind: (1) To use existing Canadian research and development facilities wherever possible to meet the needs of the Armed Forces. (2) To maintain collaboration with the United Kingdom and United States on a partnership basis. (This permits the Board to concentrate its efforts on a limited number of problems of particular importance to Canada or for which Canada possesses unique resources or facilities.) (3) To promote in every way possible the progress of standardization, a subject of vital Canadian concern.

The value of the Defence Research Board's physical assets, comprising mainly eleven well-equipped permanent scientific laboratories, totals about 32,000,000 dollars. Almost 4,500,000 dollars was invested in the facilities which existed at Valcartier, P.Q., and Suffield, Alta., when they were Armed Services' establishments prior to 1947. New construction during the past decade, therefore, at these and at the Board's other establishments represents a total expenditure of about 27,500,000 dollars. The resulting modern research facilities will help to serve for many years to come the defence scientific interests of Canada.

The total appropriation requested for defence research and development in 1956–57 was almost 80,000,000 dollars, of which approximately 24,000,000 dollars will be used for research. This sum covers the operational costs of the Board's establishments and its liaison offices in London and Washington, and its annual 1,000,000 dollars for its programme of grants and contracts for fundamental research with Canadian universities. The remainder of the appropriation covers the development activities of the three Services.

The staff of the Defence Research Board has increased from a handful of scientists, seconded Service officers and administrative personnel early in 1947 to a total of 2,800, of whom 650 are employed in professional categories. In addition, scientists and others with highly specialized knowledge from the scientific community sit voluntarily in consulting capacities on a wide variety of panels and committees concerned with the Board's programme.

The investigations carried out by the Defence Research Board involve a variety of scientific disciplines and fields. The research areas concerned include geophysics and the Arctic, electronics and telecommunications, medical and environmental protection, materials, aeronautics, civil defence, operational research and guided missiles. Studies and appraisals of equipment and weapons of the three Armed Services are maintained on a continuous basis with the view of developing new items and improving existing ones.

The Board's naval research activities are carried out at the Naval Research Establishment and the Pacific Naval Laboratory in Dartmouth, N.S., and Esquimalt, B.C., respectively. The weapons programme is concentrated at the Canadian Armament Research and Development Establishment at Valcartier, P.Q., and investigations in the methods of protection against animal diseases are carried out at a small establishment on Grosse Ile in the St. Lawrence River near Quebec City.

In Ottawa, the Defence Research Telecommunications Establishment and the Defence Research Chemical Laboratories are just beyond the eastern and western approaches to the city, respectively. Headquarters activities are carried out at National Defence Headquarters, where an Operational Research Group is also co-ordinated with the Defence Research Board Services programme in this new scientific field.

The Board's biological research programme is conducted at the Defence Research Kingston Laboratory in Kingston, Ont., and its medical activities at the Defence Research Medical Laboratories at Downsview, Ont. The latter establishment is concerned with investigating methods of using the Serviceman's physical capabilities to their fullest extent and with matching them to the complex machines he operates, rather than with curing the ill.

Activities at the Defence Research Northern Laboratory at Fort Churchill, Man., involve Arctic research. Until recently, emphasis was placed on developing techniques and methods of assisting troops to operate effectively under severe weather conditions. Cold-weather trials involving both men and equipment have been particularly important fields for study. The Laboratory now provides facilities for visiting scientists from Canada, the United Kingdom and the United States engaged in conducting northern investigations. During the next two years, the Laboratory will serve particularly as a scientific base for many of Canada's International Geophysical Year operations. Scientists of the Board will assist an American rocket team in launching a series of missiles with instrumented nose cones in support of upper atmospheric research.

At Suffield, Alta., near Medicine Hat, staff scientists conduct trials and experimental activities connected with the defensive aspects of biological, chemical and flame warfare. An important entomological programme, completed recently, resulted in the development of useful methods of controlling forest and crop pests by air-spray techniques. The station is ideally located on the prairies for trials and experiments, and its thousand square miles of rolling terrain provide unsurpassed physical facilities for such operations.

The Board has gained international recognition for some of its scientific activities, several of which promise useful civilian implications. Among these are anti-corrosion techniques to protect ships' hulls, a rocket-type anti-tank weapon with impressive accuracy, development of the detection unit installed in the Mid-Canada Early Warning Line, upper atmospheric research, development of ration and survival packs and dehydrated food techniques and an active role in promoting in Canada knowledge of guided missiles.

Recent changes in emphasis in the Board's scientific programme have involved an increasing interest in atomic activities, including the participation by members of its staff in last year's British–Australian atom bomb trials, an expanding use of electronic aids in many fields of defence science and in co-operation with the United Kingdom and the United States, a series of studies concerning certain phases of the defence against intercontinental ballistics missiles and, particularly, methods of countering attacks by such weapons.

The work achieved by scientists of the Defence Research Board during the past ten years provides them to-day with the confidence necessary for their second decade of operations.

OBITUARY

Mr. Atholl Blair, C.B.E.

Mr. Atholl Blair died suddenly at his home in Belfast last month at the age of seventy-one. He had spent a lifetime in the service of Messrs. Harland and Wolff, and was probably the world's leading builder of all forms of marine propelling machinery. When he retired in 1953 from the firm with which he had served his apprenticeship as an articled pupil he occupied the position of engine works manager and was a director of the firm. His services were retained as a consultant, however, and he remained a most active man until his sudden death.

Atholl Blair was the son of the late Sir Robert Blair, a distinguished educational administrator who occupied the position of chief education officer to the London County Council. Before succeeding to that appointment Sir Robert had gone to Ireland at the turn of the century to set up the system of technical education in that country, and his son Atholl, after going to school in Edinburgh and Dublin, attended the City and Guilds Engineering College, where he studied under the late Prof. Dalby.

With this background it is not surprising that Mr. Blair at all times took a keen interest in technical education, and it is characteristic of the man that, long before industry began to show its present concern in this vital activity, Mr. Blair was much occupied in it from the point of view of his apprentices and of their welfare. He was the first chairman of the Joint Committee for the award of National Certificates in Northern Ireland and later became a member of the Committee of the Belfast College of Technology.

Atholl Blair's professional career was a most impressive one. His contribution to the national

effort in two world wars was massive. He expected a great deal from his subordinates and demanded more from himself. For all this he will be long remembered, but those who were privileged to share his friendship will greatly miss the loyalty and warm human understanding of a man of sterling character. In his busy life he had not much time for taking part in formal activities outside his work, but he had a sound knowledge of art and a keen interest in the world around him. He at one time prepared to take up architecture as a career, and must have derived satisfaction from the fact that one of his sons became an architect and the other an engineer.

D. H. Alexander

NEWS and VIEWS

Orbit of the Artificial Earth Satellite

The artificial Earth satellite was launched from the U.S.S.R. on October 4. By a considerable feat of improvization, Mr. Martin Ryle and his team at the Mullard Radio Astronomy Observatory near Cambridge have been able to record the radio signals transmitted by the artificial satellite from October 5. Improvement of the technique has provided results from which a preliminary orbit has been calculated (*Brit. Astron. Assoc. Circular*, No. 390; October 15, 1957):

Epoch		October 8–9, 1957
Inclination	i'	64·9° (from two methods)
Eccentricity	e	0·06
Period	P	96m. 2s.; − 1·5s. a day
Maximum height		970 km. (630 mi.), at latitude − 45° approx.
Minimum height		190 km. (118 mi.), at latitude + 45° approx.
Precession of node		3° 40′ a day.

A report from the United States gives the maximum height of the orbit above the Earth as 583 miles and the minimum as 143 miles, and states that the carrier rocket was travelling three minutes ahead of the satellite on October 12. An important feature of the elliptical path, which will enable valuable information of the outer atmosphere to be obtained, is that it runs into and then out of the ionosphere.

A telegram from the Bureau of the International Astronomical Union gives particulars of an equatorial ellipse for the artificial satellite computed by Lautman, Slowey and McCrosky at the Smithsonian Institute, namely:

Epoch, October 9·405 U.T. 1957

v	266° 24′	(True anomaly)
ω'	61 47	} Equator 1957·0
Ω'	327 20	
i'	64 16	
φ	2 56	(e = 0·0512)
a'	1·08908	(in equatorial radii of Earth)

Mr. D. H. Sadler reports, following observations at the Royal Greenwich Observatory by K. C. Blackwell and W. A. Scott, that the carrier rocket is now visible in the British Isles in the morning twilight, the magnitude varying between about − 1 and + 3, moving at a height of about 430 km. from north-west to south-east. On October 13 it was approximately over Bournemouth at 5h. 26m. U.T., the track moving south-west, parallel to itself, about 200 km. a day. The time will be earlier by about two or three min. a day. The satellite itself follows behind the rocket, at present by about five minutes.

New Atomic Patents

The specifications of three patents developed within the United Kingdom Atomic Energy Authority are about to become generally available. They are all connected with the design of the graphite structure used in the building of Calder Hall nuclear power station. A number of factors influence the design of graphite moderators, one of the most important being the phenomenon of growth under irradiation (generally referred to as Wigner growth) and this is affected by the quality of graphite, the direction of grain, neutron bombardment and temperature, and in turn led to careful consideration of the design of individual blocks. The production of the graphite itself was the subject of intensive study, and quality varies between the outer perimeter and the centre. The patents involved, which also include details of fuel element support, are: No. 784,291, open for inspection on October 9; No. 784,292, open for inspection on October 9; No. 785,876, open for inspection on November 6. Specifications may be obtained from the Patent Office (Sales Branch), 25 Southampton Buildings, London, W.C.2, price 3*s.* 6*d.*, including postage.

Proton-Synchrotron at Harwell

The Governing Board of the National Institute for Research in Nuclear Science announces that a contract has now been signed for the supply of the magnet yoke which is a major component of the 7,000 million eV. proton-synchrotron being built for it on a site adjacent to the Atomic Energy Research Establishment at Harwell. The contract has been signed with Messrs. Joseph Sankey and Sons, Ltd., who have undertaken to supply the 340 steel blocks required, each weighing twenty tons, at a total cost of more than £1,250,000. The special steel required will be supplied by the Steel Company of Wales.

Thermionic Valves

On October 3, Mr. T. E. Goldup delivered his inaugural address as president of the Institution of Electrical Engineers for the session 1957–58, his main subject being thermionic valves. After briefly tracing the history of the great strides made in this field over the past fifty years, he dealt in some detail with several examples of modern developments, and with the new manufacturing processes it has been necessary to devise for the successful and economic exploitation of the results of research; these processes were illustrated by means of a short film. From the simple beginnings of Fleming's diode and de Forest's triode the field of thermionic valves has extended to include microwave valves, television camera tubes, transistors and 'masers', and a whole family of related devices which have become an all-important factor in every branch of engineering and science—a factor which more than any other has not only shaped but determined the progress in electrical engineering as it is known to-day. Mr. Goldup also referred in his address to the urgent need for a great increase in the number of adequately trained engineers and scientists, and discussed some of the associated

problems of technological education. He concluded by directing attention to the moral responsibility which, in his opinion, scientists and engineers should assume for the manner in which their work is used.

The Australian Journal of Science

COMMENCING with Vol. 20 (July 1957), the *Australian Journal of Science*, the organ of the Australian and New Zealand Association for the Advancement of Science, will be published nine, instead of six, times a year. The *Journal* is issued free to Fellows and annual members of the Association; for non-members the annual subscription, formerly 25*s.*, is increased to £A2; but the cost per issue remains unchanged at 4*s.* 6*d.* Meetings of the Association are held every eighteen months and the report of each meeting is published in three special issues of the *Journal* so that two out of every three volumes of the *Journal* contain twelve numbers. The report of the proceedings of the thirty-second meeting of the Association, which was held at Dunedin during January 16–23, 1957, is published in the three special issues of Vol. 19. The first (19, No. 3*a*; January 1957) contains a list of the officers of the meeting; details of the general programme; the presidential address, "Biology and Medicine", delivered by Sir Macfarlane Burnet; the Liversidge Lecture, "Molecular Hydrodynamics: the Diffusion of Molecules and Ions through Liquids", by Prof. R. H. Stokes; and the addresses of the presidents of the Sections: A (Astronomy, Mathematics and Physics), B (Chemistry), C (Geology) and D (Zoology). The titles and authors of the other papers delivered in these four sections are also included, in addition to an appreciation of Prof. A. P. Elkin, the recipient of the Mueller Medal for 1957.

Research for Industry

THE London and Home Counties Regional Advisory Council for Higher Technological Education has issued a further survey of industrial research in progress in technical colleges in the region in 1956 under the title "Research for Industry" (Pp. 20. 1*s.* 6*d.*). The survey shows that since the previous report was issued in 1954, covering the period 1947–52, there has been a marked development of collaboration between industry and the technical colleges. The report lists the investigations in progress, their sponsors and the technical college where they were undertaken. Besides work sponsored directly from industry, numerous investigations are being carried out for research associations, for Government departments, particularly the Ministry of Supply, for the Atomic Energy Authority, and for the Central Electricity Authority, while others are financed by grants from the Department of Scientific and Industrial Research. At Chelsea Polytechnic, the Medical Research Council is supporting an investigation on the preparation of substituted triazaphenanthrenes of potential chemotherapeutic value, the British Empire Cancer Campaign is paying for electro-kinetic studies of bacterial surfaces, while at Acton Technical College studies in the flow between management and industry are being conducted for the Tavistock Institute of Human Relations.

Economic Developments in the Middle East

"ECONOMIC Developments in the Middle East, 1955–56" (London: H.M.S.O. 11*s.*), is part of the survey of the world economic situation prepared by the Secretariat of the United Nations, and issued as a supplement to *World Economic Survey*, 1956. Besides chapters on agriculture, industry, petroleum, foreign trade, and on monetary and fiscal charges and the price-level, it includes a preliminary review of the economic impact of the Suez Canal crisis on the Middle East. During the period, demand for Middle East exports maintained its upward trend, chiefly for petroleum, but also notably for cotton, the share of the U.S.S.R. and eastern Europe rising and that of Western Europe declining. There were comparable increases and shifts in imports and their sources of supply. There was little change in the inflow of capital, and among development projects the major emphasis was on agriculture, irrigation and transport. Two major dams were completed in Iraq and two others in Turkey, and also the railroad from Tehran to Meshed in north-east Iran. The annual rate of increase in production of crude petroleum rose from 12·8 per cent in 1954 to 18·3 per cent in 1955 but decreased in 1956, mainly owing to the sharp decline in the last two months of the year. Expansion of refining capacity in 1955 raised the crude annual charging capacity of the region to more than 66 million tons, and in the autumn of 1956 the twenty refineries and topping plants were operating at 50 million tons per annum, an increase of about 35 per cent over the average for 1955, when the region processed 23 per cent of its production or 5·6 per cent of the world's refined products; the figure for 1956 is probably higher. Industrial output increased sharply in 1955, but the overall increase in 1956 was probably less.

The Pacific Science Board

THE tenth annual report of the Pacific Science Board (pp. 50. Washington, D.C.: National Academy of Sciences) records that the principal scientific activity in Micronesia has been the coral atoll programme, involving an ecological approach to the study of environmental factors affecting life on coral atolls. H. J. Wiens continued his interpretive study of man and Nature in the atoll environment, and besides visiting thirteen atolls in the Marshall Islands to study the individual features of different coral atolls, he was able to obtain comparative information on the human ecology of the Marshallese to relate to his findings in the Caroline Islands. F. R. Fosberg obtained comparative information in a visit to the Maldive Islands. Three numbers of the *Atoll Research Bulletin* were issued and twelve volumes on insects of Micronesia. Field-work continued in the three-year study of the biology and ecology of Pacific island rats at Ponape, Eastern Carolines, where valuable information is being acquired on the natural history and ecology of rats, and the field team co-operated with the Trust Territory's biennial training programme for sanitary officers by conducting a programme on rodent control. A study of sea turtles by J. R. Hendrickson has special reference to measures to assure the conservation of the turtle, and support was again given to the marine biological programme of the George Vanderbilt Foundation at Stanford University, which included investigations on the relations of fishes to their environment, the study of the estuarine-mangroves and fresh-water fishes of the Palau Islands, an entomological survey of scale insects and a study of sea currents about the Palau Islands.

National Bibliography of Nigeria

"Nigerian Publications", 1956, the fifth issue of Nigeria's current national bibliography (pp. 39. Ibadan Univ. Press. 10*s*.), lists all works received under the Publications Ordinance by Ibadan University College Library during January–December 1956. These are arranged by author, works in the English language being listed first, followed by separate lists of works in the several vernaculars. There are also lists of new Nigerian periodicals, of changes of title and of those which ceased publication during the year, and finally of recent works on Nigeria and by Nigerians published outside Nigeria. The Librarian notes a sharp drop in the number of works published in Nigeria, from 599 in 1955 to 348 in 1956, half of which are now Government publications compared with 26 per cent in 1955. The vernacular languages, however, are declining ; in 1956 they were responsible for only 9 per cent of the total. Creative writing is almost entirely absent.

Progressive *Verticillium* Wilt of Hops at Wye College

As stated in the recently published annual report of the Wye College Department of Hop Research, a single plant in one of the College hop gardens was found in 1956 to be infected with *Verticillium albo-atrum*. An outbreak of progressive wilt having been treated on the College farm in 1955, this new case was at once suspected to be progressive wilt. The report envisaged the possibility that if this recent diagnosis was also confirmed, Wye College might be forced to accept the status of a 'wilt farm', a step which would raise major issues of policy. During the 1957 season, no further cases of *V. albo-atrum* in hops have been found at Wye, and pathogenicity tests with the fungus from the 1956 case have been carried out by the National Agricultural Advisory Service and by East Malling Research Station. The results of these tests clearly show that this 1956 infection was not progressive wilt but was due to the non-serious or fluctuating strain of the fungus. No case of progressive wilt (caused by the virulent or lethal strain) has therefore been recorded in the College hop gardens for two years and it appears probable that the drastic control measures carried out in 1955 have been successful in suppressing the only known outbreak. In view of this, hop research will continue at Wye without any radical change in policy. Provided no further cases of wilt occur, the College Farm will in a few years be declared officially to be an uninfected area. Meanwhile the present strict regulations prohibiting visits to the gardens and the release of all planting material remain in force.

Agricultural and Forestry Research in East Africa

Many interesting lines of work are described in the research report for 1956 issued by the East African Agriculture and Forestry Research Organization. Most of the problems under investigation are of a long-term or inter-territorial nature. This is well illustrated by the three experiments, one in Tanganyika and two in Kenya co-ordinated by the Physics Division, on the effect of changes in land-use in high catchment areas on the evenness of river flows. The factors controlling the rate of decomposition of humus have been studied by the Chemistry Division and their results appear to offer an explanation both of the beneficial effects of burning and also of the nitrate flush at the start of the rains, and it seems likely that these findings may have a fairly general application on other tropical and sub-tropical soils. In the Forestry Division, special attention has been paid to nursery and transplant bed techniques for the production of exotic softwoods. Considerable success has been obtained and demonstrations of the new methods are being made in the Territories. Measurement of the yield of grasslands has formed an important part of the work in the Animal Industry Division, and it is now realized that the size of the experimental plot needed to achieve a ten per cent coefficient of variation is much larger than was expected. This is due to the seasonal aridity, uniformity of growth comparable with that of temperate pastures being found during the rainy season only. In feeding trials with sheep and cattle the total percentage content of crude protein in the fodder proved to be the most important factor determining its digestibility, and a statistical examination of the data from all the digestibility trials in East Africa and of many other parts of the world showed this to be true of both temperate and tropical regions.

Tokyo Astronomical Observatory

Tokyo Astronomical Bulletins issued between January 20 and May 20, 1957, consist mainly of tabular matter relating to observations made at Tokyo Astronomical Observatory. No. 92 does not deal with observations, but is entitled "Some Improvements of Short Wave Receivers for Time Signal Reception" ; it describes how frequency-amplitude characteristics of the receivers at Tokyo Astronomical Observatory were improved so that there has been a decrease in the delay times and wave-form distortion in order to meet the present methods of registering and request for high accuracy. No. 94, "Scanning Photoelectric Photometer and Method of Observation of Night Airglow for the International Geophysical Year", describes some improvements made in the two sets of scanning photoelectric photometers that have been in use for about four years for the observation of the green line in the night airglow at the Tokyo Observatory.

Fluorescence of Impurities

When a small quantity (about 1 part in 10^5) of tetracene (the 'impurity') is added to anthracene (the matrix) the fluorescence of the anthracene is suppressed and tetracene fluorescence of high efficiency appears. With increase of the concentration of the tetracene the intensity of the tetracene fluorescence increases and that of the anthracene decreases. A similar process takes place when tetracene is added to naphthalene, or anthracene to naphthalene, etc. The emission of the impurity is said to take place by means of a transfer of the absorbed energy of radiation from the matrix molecules to the impurity molecules, and a necessary condition for this is that the fluorescence of the impurity molecules should lie at longer wavelengths than that of the matrix. The energy-transfer process in solids has most often been studied in systems of the polyacenes and related molecules. A guide to the literature connected with the process entitled "Energy Transfer in Polyacene Solid Solutions" has recently been compiled by F. R. Lipsett (pp. ii+64. Ottawa : National Research Council, 1957. 50 cents). It is divided into six sections, dealing respectively

with books on luminescence and spectra and related subjects; review articles and papers on theories of spectra; experiments on spectra; energy transfer, including exciton theory and experiments on liquid solutions, solids, glasses, plastics, inorganic compounds and gases; related subjects, including photo- and semi-conduction and electroluminescence; and experimental techniques, including crystal growth and sample preparation. The guide is by no means exhaustive, but the papers have been carefully selected, the criterion for the selection being their usefulness in elucidation of the energy transfer process.

Perkin Centenary Trust Awards

THE Perkin Centenary Trust was established to commemorate the discovery of 'Mauveine' by William Henry Perkin in the year 1856 and to promote technical education in all aspects of the manufacture and application of colouring matters. The Trustees offer the following awards for the academic year 1958–59: (1) *The Perkin Centenary Fellowship*, for one or two years, to a graduate for the purpose of higher study. It has a value of not less than £600 per annum, and is tenable, from October 1958, at any university, technical college, or other institution approved by the Trustees. (2) *Two Perkin Centenary Scholarships*, each for two years starting in October 1958 and renewable at the discretion of the Trustees for one further year, to enable candidates employed in an industrial firm or other institution concerned with the manufacture or the application of colouring matters to receive an education at a university or technical college. Each award will have a value of £300 per annum. There is no means test for the award, and a successful candidate is not debarred from receiving the whole or a part of his normal salary from his employers during his tenure of the scholarship. (3) *Perkin Exchange Lectureships*. An appointment will be made from time to time by the Trustees to enable a senior teacher at any appropriate university, or technical college, or other institution, to visit some similar establishment overseas in order to deliver a short course of lectures. In return, a visit to a British institution by some overseas scientist will be arranged. A second appointment contemplated will permit the exchange of lecturers for a period of up to one year between comparable institutions in Britain and overseas. Further information can be obtained from the Secretary, The Perkin Centenary Trust, c/o The Chemical Society, Burlington House, London, W.1. Applications for the awards must be made by May 1, 1958.

B.B.C. Research Scholarships

THE B.B.C. has awarded two research scholarships, valued at £435 per annum, to university graduates in electrical engineering, giving them the opportunity to work for a higher degree at any university in the United Kingdom. The first is to Mr. J. B. Izatt, who graduated at the University of Aberdeen. Mr. Izatt will conduct his researches at the Robert Gordon's Technical College under the guidance of Dr. E. Wilkinson and Mr. A. M. Hardie. The second scholarship has been awarded to Mr. W. A. G. Voss, who graduated at Queen Mary College, University of London. Mr. Voss will conduct his researches there under the guidance of Prof. M. W. Humphrey Davies. The scholarships, which are awarded annually, are for two years in the first instance with the possibility of extension in suitable cases. The scholarships are limited to male British subjects normally resident in the United Kingdom, and the only condition applying to the subject for research is that it must have an application to sound or television broadcasting.

Announcements

THE World Meteorological Organization has posthumously awarded the annual prize created to commemorate the International Meteorological Organization to the late Prof. Carl Gustaf Rossby, of Stockholm, who died on August 19.

PROF. J. H. GADDUM has been appointed director of the Agricultural Research Council Institute of Animal Physiology, Babraham, Cambridge, as from September 30, 1958, when Dr. I. de Burgh Daly, the present director, is to retire.

MR. P. A. HUFTON has been appointed head of the Aerodynamics Department, Royal Aircraft Establishment, Bedford, and Dr. D. Kuchemann has been appointed to succeed Mr. Hufton as head of the Supersonics Division of the Aerodynamics Department.

DR. JAMES REEKIE has been appointed chief engineer to Semiconductors, Ltd., Ilford, Essex. For the past twelve years Dr. Reekie has been in Canada, where he was professor of physics at the University of Toronto, and later, head of the Department of Physics at the Royal Military College of Canada. Prior to joining Semiconductors, Ltd., Dr. Reekie, who has been responsible for a considerable number of technical publications in the field of solid state physics, was research director in semiconductors and solid state physics for the Northern Electric Company, Montreal.

THE United Kingdom Atomic Energy Authority will be unable to accept further applications to visit their establishment at Dounreay for several months. The fast breeder reactor is now nearing completion and the staff of the station will be under heavy pressure in supervising its completion and commissioning.

W. WATSON AND SONS, LTD., are to hold an exhibition on the theme of "The Microscope in Industry and Research" at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2, during November 4–8. A catalogue of exhibits may be obtained from W. Watson and Sons, Ltd., 313 High Holborn, London, W.C.1, to whom all inquiries should be addressed.

THE Hatfield Memorial Lecture of the Iron and Steel Institute will be held at 6.30 p.m. on November 28 in the Firth Hall of the University of Sheffield. It will be given by Prof. Paul Bastien, director of research of the Société des Forges et Ateliers du Creusot, whose subject will be "The Mechanism of the Formation of Banded Structures in Steel". Applications for tickets should be made to the Registrar, The University, Sheffield 10.

A REVIEW of Iredale's "Birds of New Guinea" was published in *Nature* of October 5, p. 675. The distributors of this work in the United Kingdom are Phoenix House, Ltd., 38 William IV Street, Charing Cross, London, W.C.2.

LATENT VIRUS INFECTIONS

THERE is increasing recognition that many virus infections, of animals, higher plants and bacteria, are present in the absence of overt symptoms and signs. Some of them become activated by the most various stimuli, and there is thus bred confusion as to the true causes of some diseases. Some insect viruses, when introduced into an insect which is not their natural host, may activate a virus latent in that host, starting off a serially transmissible disease which is not essentially caused by the virus first used. Study of these phenomena is made difficult by the lack of uniformity in the use by workers concerned of certain key words such as 'latent', 'inapparent', 'subclinical', 'masked'.

A symposium on "Latency and Masking in Viral and Rickettsial Infections" was held during September 4–6 on the University campus at Madison, Wisconsin. It was supported by the Rockefeller Foundation and the Wisconsin Alumni Research Foundation. About 225 people attended. The object was to exchange views on the mechanisms of latent infections and more particularly to try to reach some agreement concerning the proper use of relevant words. After the reading and discussing of the papers presented, there was, on each day, a more general debate under the ægis of a moderator, participated in both by a panel on the platform and by speakers from the body of the hall.

In an opening address, C. H. Andrewes (London) made a general survey of the field and put forward tentative suggestions as to the use of some important words. He emphasized, as did subsequent speakers, that the matter must be considered both at the host–parasite and the cell–virus level. He was followed by André Lwoff (Paris), who discussed lysogeny and the prophage–phage soquence as examples of latent infection of bacteria and its activation by ultra-violet rays and other stimuli. J. W. Beard (Durham, North Carolina) was much concerned about the use of the terms masking and masked virus. Shope first used the terms in virology for describing the state of affairs in which papillomata grew progressively in domestic rabbits, yet virus was hard to demonstrate except by indirect means. He believed that virus was present in a qualitatively changed state. Beard, on the other hand, held that the facts could be more simply explained by presence of virus in very small amounts: he felt that the term 'masked' should be either rigidly defined or abandoned. R. Dulbecco (Pasadena) discussed temperate phages, which readily enter into a lysogenic relationship with bacteria; and the contrasting virulent phages which lead to lysis. He proposed the terms moderate, semi-moderate and virulent for describing corresponding relationships between the host-cells and viruses of animals and higher plants. Later, sub-moderate was preferred to semi-moderate and cytocidal to virulent.

R. J. Huebner (Bethesda) described latent infections with adenoviruses, salivary viruses and herpes; he felt that there was a virus-group in which presence of intranuclear inclusions was associated with a tendency to persisting infection. J. E. Hotchin (Albany, New York) reported studies of lymphocytic choriomeningitis in mice, extending Traub's classical findings. His work supported the idea that immunological tolerance might explain how, in mice infected *in utero*, persistent infection occurred, with absence of antibody formation or tissue reaction.

F. C. Bawden (Rothamsted) discussed the varying relations between higher plants and viruses, in particular the latency of paracrinkle virus in King Edward potatoes. He was inclined to make use of the word 'commensalism'.

Several workers described latent infections of viruses in tissue culture. T. T. Puck (Denver) spoke of cells chronically carrying Newcastle disease virus; the latent infection became manifest when they were plated on to a monolayer of highly susceptible irradiated cells. F. Deinhardt (Philadelphia) had studied similar cell lines carrying Newcastle disease virus or mumps virus. It appeared that only one in fifty of cells latently infected with Newcastle disease virus would liberate active virus, yet all were relatively resistant to infection with vesicular stomatitis virus. W. W. Ackerman (Ann Arbor) described somewhat similar experiments with poliomyelitis-infected cultures; and H. S. Ginsberg (Cleveland) spoke of experiments on latent infections of cultures with adenoviruses. H. R. Morgan (Rochester, N.Y.) had kept psittacosis virus in a latent state by starving his cultures: a good nutritive medium would activate the virus and apparently certain amino-acids and water-soluble vitamins were especially effective. C. B. Philip (Montana) spoke of a similar situation in ticks infected with rickettsiæ of rocky mountain spotted fever. The rickettsiæ were non-infectious in starved ticks but could be activated by feeding or incubation.

During discussion, Huebner mentioned a latent infection of HeLa cells with a virus which finally "turned his cultures into one giant cell". This virus was propagable in eggs, and antibodies were present in all human sera except those of early childhood.

In a final session for general appraisal and definition of terms, questions at issue were batted back and forth between the floor of the house and a panel consisting of Andrewes (moderator), Bawden, Beard, Dulbecco and Lwoff. Lwoff had prepared a document containing a number of definitions, and this served as a useful basis for discussion. Since practically every speaker earlier on had used the words 'latent', etc., in a different sense, it was surprising that a considerable measure of agreement was ultimately reached. There was in fact a fair consensus of opinion on the following points.

At the host–parasite level, 'inapparent infection' covers the whole field of infections which give no overt signs of their presence. 'Latent' infection' denotes those cases of inapparent infection which are chronic and in which a certain host–virus equilibrium is established. No special word was recommended to describe inapparent infections of limited duration ('infection inapparente' in Nicolle's original sense), but it was recognized that the term 'subclinical' would continue to be used for many such infections of man and other species. (Most delegates were apparently very surprised to hear that the word 'clinical' originally had reference to 'bed'.) It was suggested that the term 'latent virus' be not used: confusion would seem inevitable if the same adjective

were applied to 'infection' and to 'virus', since the meaning of 'latent' would necessarily be different in the two cases.

As regards the word 'masked' there seemed no possibility of obtaining agreement. It was suggested, therefore, that its use should not be encouraged but that 'occult virus' should be used instead. Among the definitions of occult provided by the Oxford dictionary were: "communicated only to the initiated; not apprehensible to the mind". The word 'occult' should cover "the cases where infective particles cannot be detected and in which the actual state of the virus cannot as yet be ascertained". Thus we might be unable to recover virus from an infected host but might be ignorant as to whether it was qualitatively altered or present in minute quantity or mixed with antibody. We should need a word to describe our state of ignorance: other more descriptive words could be used when the reason for the occult state had been discovered.

At the cell–virus level, it was agreed that a provirus, corresponding to prophage, had not been proved to exist, but that if and when other viruses were shown to pass through cycles like that of phage, the words 'provirus', 'vegetative virus' and 'infectious virus' would be appropriate to describe the corresponding stages.

Dulbecco's term 'moderate virus' was approved to denote a virus which grew in a cell while still permitting its continued survival and multiplication: 'cytocidal' described one which killed it: 'submoderate' covered intermediate cases. Clearly, some viruses are moderate for one cell-system, cytocidal for another: so the words are only relevant to particular virus-cell systems. It is important to note also that a virus may be cytocidal for some dispensable cells in a host, yet these may be at any one time few in number so that the infection as a whole is inapparent.

The proceedings of the symposium will be published shortly by the Burgess Press, Minneapolis.

C. H. Andrewes

BIOLOGY OF THE SALMON

A SYMPOSIUM on the "Biology of the Salmon" was held on September 10 by Section D (Zoology) of the British Association meeting in Dublin.

Dr. A. E. J. Went opened the symposium with a paper entitled "Salmon Investigations in Ireland, with particular reference to the River Shannon". He pointed out that if it had been necessary to purchase salmon for investigation, progress would have been very slow owing to the great expense of obtaining fish; but fortunately a considerable amount of information can be obtained about an individual salmon by microscopic examination of its scales. The scale of a salmon is a life and birth certificate, and it was by this means that the late Rowland Southern in 1924 started his investigations into the salmon of the River Shannon which was then about to be harnessed for hydro-electric purposes.

Southern's first paper in 1928 indicated in a general way the age and growth of salmon of the River Shannon in the years 1924–26 inclusive, and afterwards the investigations into the runs of fish in 1927 and 1928 were carried on by Went, using material from salmon taken in the ancient Lax Weir near Limerick. From 1941 onwards similar material has been collected annually from salmon taken in the Thomond Weir near Limerick.

Prior to the operation of the hydro-electric plant the Shannon was predominantly an early-salmon river; that is to say, the bulk of the fish had spent two or more years feeding in the sea. Taking the year 1928 as representative of the pre-hydro-electric scheme stocks and the year 1941 as representative of the post-hydro-electric scheme stocks, the differences in the stocks may be summarized briefly as follows: (1) the average age of the smolts was higher in 1941 (2·08 years) than in 1928 (1·98 years); (2) the grilse amounted to 75 per cent of the total run of 1941, whereas in 1928 the figure was 24·7 per cent; (3) in 1941, 70 per cent of the total run occurred in the month of June, whereas in 1928 that month's catch amounted to only 27·5 per cent of the total; (4) the age of the fish in 1941 was approximately one year less than in 1928; (5) the average size of salmon entering the river in 1941 was much smaller than in 1928.

By a series of calculations it was found possible to estimate the relationship of the size of the 1928 and 1941 runs. By this method it could be shown that the grilse have not actually increased but they have remained relatively static over the years. Those age-groups of salmon which have spent two or more years feeding in the sea have been very much reduced and the present stocks of the River Shannon are about 30–40 per cent of those of the pre-hydro-electric scheme days. This change seems to be associated with the 'dewatering' of the main spawning beds for large salmon in the old channel of the Shannon between Killaloe and Limerick. This might account for the loss of the earlier running or larger fish. On the other hand, the Mulcair River, which is the major spawning tributary of the Shannon to-day, always was the major spawning ground for the smaller fish.

Adequate material has now been collected annually from 1941 to date and it has been possible to follow the changes in the sizes of the stocks and to estimate the yield (as adult fish) from a number of brood years from 1942 to 1951. Variations in the number of fish derived from the different brood years during this period have ranged from 16,100 for 1950 to 6,400 for 1942.

At this stage Miss E. Twomey took up the story with her paper, "The Age and Growth of Irish Salmon". She gave the results of investigations into the age and growth of the salmon of various Irish rivers, again using collections of salmon scales and data relating to the weight, length and date of capture of the fish concerned. Salmon in Irish rivers spend 1–4 years before migrating to the sea for the first time. The majority of fish, however, spend two years in the fresh water, the one-year old smolts generally being next in importance. Only a few four-year olds have been identified from Irish rivers.

Two types of smolts have been identified in Irish rivers, namely, those which show little or no growth in fresh water in the spring prior to the smolt descent, and those which showed considerable growth. These types have been described by Went as type *A* and type *B* smolts, respectively. All the one-year smolts were of type *B*, and in the older smolt classes both types were found; the proportion of type *A* increased gradually as the smolt age is ascended.

There is considerable variation in the length at which smolts migrate. In the Rivers Liffey and Lee they migrate at an average length of about 16 cm., whereas in other rivers they may migrate at lengths of less than 12·5 cm.

The fastest-growing fish in each river appear to migrate first, and there is generally a slight increase in the average length of the smolt as the smolt ages are ascended.

Spring fish which have spent two or three years feeding in the sea predominate in some Irish rivers such as the Liffey and Lee, whereas on the other extreme some are virtually grilse rivers; that is to say, the fish have spent less than two full years feeding in the sea. In rivers which have no lakes on their systems and with intensive commercial fisheries the proportion of previous spawners is low. This is the case of the Rivers Liffey, Lee, Inny and Kerry Blackwater. In most rivers having lakes on their systems the proportion of previous spawners is high. For Ireland as a whole the proportion of previous spawners ranges from 1 to 15 per cent, depending on the river and to some extent on the year, with an average of about 5 per cent. Most of the previous spawners have only a single spawning mark on their scales, a smaller proportion, about 3 per cent, have two; a few have three such marks on their scales. Fish with three spawning marks have only been identified on six occasions out of a total of nearly fifty thousand sets of Irish salmon scales examined to date.

Thus by using the scales a considerable amount of information has been compiled about the salmon of Irish rivers; but as Miss Twomey pointed out, other methods have to be employed to investigate other aspects of the life-history of Irish salmon.

Mr. E. D. Toner in his paper, "Movements of Salmon in the Sea around Ireland", then described the progress made in investigations in the open seas around Ireland since 1948 when the experiments were initiated. Live salmon taken in commercial nets were tagged with the Lea hydrostatic tag and released at several places around the Irish coast, namely: Baginbun, Co. Wexford (south-east coast); Rath, Co. Kerry (south-west coast); Achill, Co. Mayo (west coast); Streedagh, Co. Sligo (north-west coast); Portbraddan and Carrick-a-rede, Co. Antrim (north coast) and Carnlough, Co. Antrim (north-east coast). Altogether, 3,246 salmon and grilse were so tagged and 930 tags, or 28·6 per cent, were recovered. From Baginbun the predominant movement was westerly, but a small proportion of fish moved eastwards and then northwards, two proceeding long distances, one to the River Fane on the east coast of Ireland and one to the River Tay in Scotland more than eight hundred miles away. Movements from Rath were mainly to local rivers, but a few fish proceeded a hundred miles or more northwards up the west coast. Most of the recaptures from Achill were made in rivers within fifty miles of the tagging stations, though some fish made long journeys to places on the north coast of Ireland and west coast of Scotland. Individual fish went to Rhyl in North Wales and to the Conon River on the east coast of Scotland. Movements from Streedagh were mainly to local rivers. In the stations on the north coast of Ireland the predominant movement was westwards towards the River Foyle. A small proportion of fish, however, moved to the east coast of Ireland, to the west coast of Scotland and one even to the east coast of Scotland. From Carnlough on the north-east coast the movements were again predominantly towards the west, but there were substantial movements to the west coast of Scotland, and two fish travelled to the east coast of Scotland, one to the River Tweed.

As to the speeds of travel, the maximum apparent speed recorded was thirty-three miles a day, and only ten fish out of the eight hundred or so for which information was available reached their destinations after travelling at speeds of twenty miles a day or more.

Mr. Toner concluded that salmon approach the Irish coasts in a haphazard fashion, and only when they are close inshore do they make a definite search for the river of their origin.

Mr. Arthur Swain, in his paper "Factors affecting the Downstream Migration of Salmon and Sea Trout", pointed out that the 'departure stimulus' has always been associated with floods, but as long ago as 1926 H. O. Bull showed that this was not true, although Bull concluded that the initiation of the run of smolts was associated with rainfall.

For a number of years salmon and sea trout, smolts and kelts have been caught and tagged in the River Coquet at Warkworth in Northumberland at a specially constructed set of traps. Data relating to the downstream movement of the smolts and the temperature of the water, etc., were collected during 1952–57 inclusive. During these years many thousands of smolts were caught, a very high proportion in the hours of darkness, especially the first three or four hours. Few smolts were taken in March in the years 1953–56, when the temperatures were low, but in 1957 during that month a mild spell of weather resulted in a fairly large number of smolts being caught. As a rule, large numbers of smolts appeared from about the third week in April onwards, continuing well into May, and the numbers generally began to fall off at the end of May or early June.

Mr. Swain concluded that the migration of smolts was clearly seasonable, but within the migration season it appeared that the immediate stimulus for migration is either a rise in temperature, or some factor associated with a rise in temperature, acting on fish which have attained the proper physiological condition. The stimulus which causes the kelts to move downstream, on the other hand, is clearly associated with floods, and the rate of flow and turbidity of the water encouraged them to drift downstream. There is also some evidence that they are influenced by temperature and that a rise in temperature, as in the case of smolts, stimulates them to move downstream. A. E. J. Went

IONIZATION PHENOMENA IN GASES

THE impressive history of rich contributions to the structure of contemporary physics presented by that branch concerned with the conduction of electricity in gases is well known. An indication of one reason why work in this field is at present in one of its more flourishing phases is contained in the name 'gaseous electronics'. This is a recent fashion which—though perhaps offensive to some—does recognize the extent to which the advances of the

past decade or so have depended on developments in refined ultra-high-frequency and high-speed electronic instrumentation, very-high-vacuum and gas-handling techniques, stable high-voltage sources and so on. Moreover, the actual exploitation of improved technical facilities of this kind has been accelerated by several influences, notably the persisting need for more quantitative information on fundamental collision processes, not only in laboratory discharge-physics but also in fields such as ionospheric research and astrophysics, and also by the hope that studies of the extreme conditions which exist in heavily loaded plasmas may assist ultimate achievement of controlled nuclear fusion.

The present vigour of the field under review was amply demonstrated by the scope of the Third International Conference on Ionization Phenomena in Gases, arranged at Venice during June 11–15 by the Società Italiana di Fisica, under the presidency of Prof. G. Pulvani. This conference continued a series of biennial meetings initiated by A. von Engel at Oxford in 1953, followed by a meeting at Delft in 1955. A total of some forty papers was presented in the general sessions, and ninety in three parallel specialized sessions. It is thus obvious that the present review cannot do individual justice, since a mere catalogue of titles would consume much of the available space. This account is, therefore, restricted to details of general-session reports, with some remarks on special-session papers, principally in connexion with fundamental collision processes and spark breakdown, together with a broad coverage of papers on very high temperature plasmas, pulsed discharges, and plasma theory, since these topics received special emphasis owing to their relevance to thermonuclear reactions. This selection, however, leaves unnoticed many important contributions, particularly the numerous papers on glows, electrode actions, counter processes and technical applications.

After addresses of welcome by representatives of the several host organizations, the Conference opened with an invited paper by Prof. W. Lochte-Holtgreven (Kiel), on "The Emission of Spectral Lines from a Plasma". Characteristic of the well-known work of the Kiel school on heavily loaded arcs and other discharges has been the wide exploitation of spectroscopic methods. Prof. Lochte-Holtgreven compared current theoretical interpretations of spectral line-profiles with results of recent experimental work on lines of atomic hydrogen, helium I and helium II. There has been steady progress, during the past few years, towards better understanding of the relative contributions of plasma electrons and (slower) positive ions to the shapes of the emitted lines.

Prof. L. B. Loeb (Berkeley) was, unfortunately, prevented by illness from reading a second invited paper; the sympathy and greetings of the Conference were telegraphed to Prof. Loeb, whose substantial contributions to discharge physics are well known.

Atomic and Ionic Collision Processes

The general sessions opened with a paper by R. Varney (St. Louis) on "Ionization of Gases by Positive-ion Impact", in which, in continuance of earlier work, new results were reported on efficiencies and threshold energies of ionization by positive ions of alkali metals in various gases, obtained with apparatus of greatly improved sensitivity. J. Sayers (Birmingham) reviewed ionic reactions in gases, with special reference to work at Birmingham on electron recombination, in which—by a combination of Langmuir-probe and mass-spectrometer-probe techniques—the attempt is made to account for electron loss from an afterglow in terms of capture by the specific types of positive ion detected.

Important results on photo-ionization cross-sections of gases and photoelectric-yields of solids, investigated by improved vacuum-ultraviolet methods, have emerged from several laboratories in recent years. The work at Los Angeles described by G. L. Weissler included a number of new results, one point of particular interest being the high yields of photo-ionization found in several polyatomics—five to ten times those typical of simpler gases.

Some techniques of great elegance, including very sensitive optical-absorption methods, have been developed at Westinghouse Laboratories, Pittsburgh, for studies of concentrations and interactions of excited and particularly metastable atoms; some new results were reported by A. V. Phelps. Other experiments, also of great beauty, were described by L. M. Branscomb (Washington), in a paper entitled "Photodetachment Studies of Negative Ions". In this work, a mass-analysed beam of negative ions is intensely illuminated by light selected by an interference filter, the current of photo-detached electrons is measured, and cross-sections are derived. A related paper was that of V. Dukelsky (Moscow), on "Formation of Negative Ions and Atomic Structure"; the existence of negative ions of many elements was reported, the more stable forms often being molecular. An interesting problem is posed by the mechanism of formation of the ion He^- which, although of negative electron-affinity in its ground-state, has been shown by recent theoretical work to have a stable doubly-excited quartet state of long life-time.

Papers by R. L. F. Boyd and J. B. Hasted related to different aspects of the substantial programme of collision studies and discharge investigations at University College, London. Apart from a general review, the first of these described a method of performing electrically the (Druyvesteyn) analysis of probe curves, which gives greatly improved accuracy in determinations of the energy distribution among the plasma electrons. The second paper described apparatus for collision studies—especially of ionization by positive ions, with simultaneous check by mass-spectrometer of the fragmentation products in the processes of ionization and charge-exchange.

A valuable paper, presented by L. Goldstein (Urbana) on "Charge Interactions in Gaseous Discharge Plasmas", was concerned with experimental and theoretical results on the interaction processes which occur both within an electron-gas and between electrons and ions in a plasma. Experiments on the heat-propagation properties of plasmas were said to indicate that the electron/electron interaction, for which no satisfactory theory yet exists, is important even in plasmas of low ion density.

Spark Breakdown

The subject of the mechanisms of spark breakdown was introduced in reviews by J. M. Meek (Liverpool), "Recent Researches in Spark Breakdown", and H. Raether (Hamburg), "Townsend and Streamer Mechanisms". The first stage of breakdown in a gap occupied by a uniform field consists of a rapid growth

of ionization by electron-impact, initiated by the acceleration of a single electron away from the cathode region (electron avalanche). The essential feature of the Townsend mechanism for building up the current in the gap lies in the development of fresh avalanches, in rapidly increasing numbers, as a result of the operation of one or more possible secondary processes, for example, emission of secondary electrons from the cathode due to bombardment by positive ions. Though such mechanisms have long been recognized as affording an adequate explanation of sparking phenomena for low values of the product (pressure × gap-length), until very recently severe difficulties existed at high values of that product. The streamer theory, associated with the names of Loeb, Meek, Raether, met such difficulties, at least qualitatively, by emphasizing the part played by photo-ionization of the gas and the distortion of the field produced by accumulated space-charges. However, an obviously unsatisfactory dichotomy persisted, with the employment of two widely differing theories for high and low values of the product (pressure × gap-length), leaving more or less untreated a large and ill-defined intermediate region. The most recent work has led to the belief that objections to Townsend mechanisms in spark gaps occupied by uniform fields near the critical sparking voltage have previously been over-estimated. While the subject is still very fluid, the vigour of current investigations encourages the hope that a comprehensive theory may be reached, possibly embodying a transition from 'Townsend' to 'streamer' breakdown with changing conditions.

Several other laboratories which have been active in this work were represented at the Conference. Thus, L. H. Fisher (New York), whose work on formative time-lags has been very significant, reported further results on pre-sparking phenomena in gases in uniform and non-uniform fields. F. Llewellyn-Jones (Swansea), describing some recent investigations on micro-arc discharges, dealt with breakdown mechanism and subsequent characteristics of a discharge such as that produced by the opening of an electrical contact; this work has obvious technical importance, and also faces difficulties from the small-scale nature of the phenomena. Other work at Swansea was described by C. Grey-Morgan, under the title "Electrode Ionization Phenomena in Gases". Detailed studies of the temporal relations of voltage, current and the intensity and propagation-velocity of the luminosity in over-volted impulse-sparks were reported by J. K. Theobald (Los Alamos).

The interpretation of the lightning-stroke—the extreme example of breakdown under conditions in which (pressure × gap-length) is large—is a continuing challenge to laboratory discharge physics; the value of new observational material, obtained by improved methods now available, was recognized from a paper by H. Norinder (Upsala) on "Some New Results on the Mechanism of Lightning Discharges".

In recent years much experimental and theoretical effort has been devoted to the breakdown processes in a gas subjected to an applied field at microwave frequencies. A laboratory which has been especially prominent in this respect is that of S. C. Brown (Cambridge, Mass.), who, under the title "Microwave Gas Discharge Breakdown in the Presence of Magnetic Fields", summarized the most recent results in this field.

Arcs and Glows

A number of general session papers were concerned with features of arc and glow discharges. D. J. Rose (Murray Hill), in a paper on secondary mechanisms of the glow discharge, described interesting results on the relative contributions of two processes of electron-ejection from molybdenum cathodes in hydrogen, deuterium, and neon, namely, ejection by incident positive ions and by photons. K. G. Emeleus (Belfast), in a paper with B. Love, gave an extended treatment of the complex of phenomena involved in the classification and stability of striations, and emphasized the likely value of detailed spectroscopic study of the several forms observed.

Three major papers on arc-discharges were read. In the first, H. Maecker (Erlangen), under the title "General Description of Electric Arcs and its Application to some d.c. Types", presented an amply illustrated review of the utilization of the electrical and spectral characteristics of several forms of arc channel, including uniform-cylindrical, free-burning (convection-stabilized), and high-current forms. In the second paper, on high-pressure discharges in gas mixtures, P. Schulz (Karlsruhe) discussed effects on field strength, light output and spectral distribution, in gas-arcs, in terms of relative excitation- and ionization-potentials and collision cross-sections, of the atoms of a binary gas mixture. In the third paper, on "The Anode-Drop in Low-Pressure Discharges and High-Current Arcs", K. H. Höcker (Stuttgart) distinguished the details of the processes of ion generation, supposed to be operative in the anode region of these two discharge types.

An interesting paper by A. E. Robson (Oxford), on the evaporating cathode and the Tanberg effect, was concerned with the anomaly presented by simultaneous measurements of the evaporation-rate from the molten cathode of a metal arc, and the force of reaction produced on that electrode by the evaporating atoms; these measurements have previously led to estimates of the velocities of the latter, which correspond to improbably high values for the temperature at the cathode, around half a million degrees. The explanation now suggested for this so-called 'Tanberg effect' is that the number of evaporating atoms has been greatly under-estimated, by neglect of the fact that the majority—typically 95 per cent—of those leaving the surface are scattered back again by collisions in the cathode-layer.

Of the remaining papers on arc-discharges, space permits mention of only one, by H. Edels (Liverpool), on "Glow to Arc Transition in the Column and at the Cathode of a Hydrogen Discharge", describing experiments by both electrical and spectroscopic techniques, aimed at clarification of the complex processes involved in such transitional regions.

High Temperature Plasma and Pulsed Discharges

Contributions in this and allied sections showed that work in many laboratories is centred on the problems posed by the pinched discharge, in which constriction of a plasma column results from self-magnetic pressure. A. A. Ware (Aldermaston), one of the original workers in this field, described experiments with a toroidal discharge-tube. The ions and electrons are found to be pulled in rather slowly by the pinch-effect, with the development of a central region of high pressure, from which emerges a shock wave

travelling outward. Within the shock-front the discharge passes in a narrow irregular channel. Similar irregular helical channels in toroidal discharges were reported by T. K. Allen (Harwell); during a long square current pulse (200 μsec., 4,000 amp.), rotation of the helix about the toroid-axis is indicated, at velocities 2–7 × 10^5 cm./sec., in argon and neon. P. Reynolds (Harwell) reported work with J. E. Allen, in which measurements of electron- and ion-temperature were made by several methods, using an apparatus similar to that of Ware; oscillatory currents of 15–20,000 amp. gave ion-temperatures of 5,000–40,000° K. A. N. Dellis (Harwell) described the use of microwave noise in the determination of plasma electron-temperatures; the noise at a wavelength of 8·5 mm. from a hydrogen discharge yielded electron-temperatures up to 2 × 10^5 °K.

A highlight of the Conference was the report of S. A. Colgate, of work on pinched discharges in deuterium, by a group at Livermore in the United States. These important investigations were made some years ago but have, unfortunately, remained classified until recently. As in the case of similar work done in the U.S.S.R., and reported by I. Kurchatov at Harwell in 1956, copious bursts of neutrons were obtained, which, however, are not likely to have been of true thermonuclear origin. The most significant results of the Livermore experiments leading to the latter conclusion are: (*a*) the neutrons arise in the gas, uniformly along the discharge-axis, where the temperature should be highest, (*b*) application of a small axial magnetic field quenches the production of neutrons, (*c*) the deuterons colliding to produce neutrons, by the reaction $^2D_1 + {}^2D_1 \rightarrow {}^3He_2 + {}^1n_0$, have axial velocities corresponding to energies of 200–300 kV. The suggested mechanism for the production of neutrons is that the pinched discharge becomes unstable, the uniform column splitting into 'droplets' along the axis of the tube, possibly leading to high axial electric fields in which the deuterium ions are accelerated. Quenching of the yield of neutrons by the small magnetic field is then attributed to the effect of the field in limiting the axial instability.

R. F. Post (Livermore), in a paper on problems of research into controlled fusion, amplified and revised the useful appreciation he contributed to "Reviews of Modern Physics" in 1956. The results of his latest work were given in the form of new limits for temperature, density, size and magnetic field. The need for great purity of the reacting gases was emphasized.

The production and study of heavy-current discharges were described by C. Breton *et al.* (Saclay). The apparatus used consisted of a torus, similar to those used at Aldermaston and Harwell, in which a high gradient of electric field could be induced by an oscillatory condenser discharge. The occurrence of shock-waves was demonstrated, and pulses of γ-rays of 150-kV. energy were detected. The spectroscopy of the discharges was discussed in a companion paper.

R. J. Bickerton (Harwell) described theoretical and experimental work on the effect of a stabilizing magnetic field on a toroidal discharge. Theoretically, limited regions of current and magnetic field are expected, over which the discharge should be stable, without the pinch-effect being seriously modified by the applied magnetic field. Experimental tests, using pulsed currents and fields, more or less support the theory, and ionic- and electron-temperatures of order 500,000° K. have been estimated.

Later in the Conference, three further papers on condenser discharge work were presented. The first was by K. Siegbahn (Upsala), who reported detection of neutrons in a 60-μF., 50-kV. discharge in deuterium. The other two papers, by S. Curran and K. W. Allen, related to work at Aldermaston, employing a circular arrangement of 144 condensers, connected by short leads to a centrally placed discharge-tube. Novel features, however, were the use of a separate triggered gap on each of the condensers used, and the application of a pre-ionizing pulse to the gas in the discharge tube. Pulses of up to 10^5 neutrons were obtained, and it may well be that the mechanism of production of these was different from that suggested by Colgate, since the yield of neutrons was found to be much less sensitive to concentration of nitrogen impurity and to an axial magnetic field. A paper by P. C. Thonemann and A. Gibson (Harwell) discussed the production of run-away electrons in toroidal discharges. With a stabilizing axial magnetic field of 1,000 gauss, such electrons were detected by the X-rays they produced; the energy of the electrons was estimated to be 25–30 kV., and the yield approximately one-sixth of that expected from elementary theory. H. Dreicer (Los Alamos) also discussed the run-away electron phenomena from a theoretical point of view.

M. O'Day (Cambridge, Mass.) reported work with W. G. Chace and E. W. Cullington on the explosion of wires by discharges from heavy condensers. Instrumentation, under the conditions of extreme interference which necessarily exist, presents much difficulty, and the equipment installed is probably as advanced, as regards design and screening, as any yet devised. An impedance match was achieved between the bank of condensers and the wire specimen. No pinch-effects had been observed in either solid or vapour, but it was hoped that these would be found on further increasing the rate of increase of current.

Plasma Theory

The papers presented on plasma theory covered an extremely wide field, extending from studies of distribution functions, to calculations concerning the stabilities of particular discharges. In the first session, M. Delcroix (Paris) discussed the work of a group at the École Normale Supérieure, leading to an expression of the velocity distribution function in a lightly ionized gas as a series of eigenfunctions of the collision operator. H. Schirmer (Berlin) gave a detailed account of the calculation of the electrical conductivity of a partially ionized gas, with special reference to a high-pressure xenon discharge, which was used to check the calculations. R. Jancel and T. Kahan (Paris) discussed, in two papers, the distribution function for a partially ionized gas subjected to oscillating electric and steady magnetic fields, and also the problems of wave-propagation in such a plasma. G. Schmitz (Aachen) gave an account of a method of solving the energy-balance equation for a cylindrical plasma channel, in which the thermal and electrical conductivities are known functions of temperature.

The second session, which was mainly concerned with the fundamentals of plasma stability, was opened by M. Kruskal (Princeton), well known for his pioneer work with Schwarzschild on the stability of a pinched discharge. Two papers were presented, both con-

cerned with invariants of motion in ionized gases. The first dealt with the spiralling of charged particles of small ratio (ε) of mass to charge. An adiabatic invariant, which has been discussed by H. Alfvén, for the case $\varepsilon = 0$, was generalized to all powers of ε. The second paper, with I. Bernstein, E. Frieman and R. Kulsrud, gave an energy principle for examining the stability of a discharge channel of more general application than the customary 'normal-mode' approach.

The group at Göttingen, L. Biermann, K. Hain, R. Lüst and A. Schlüter, also reported a detailed study of the problems of hydromagnetic stability. In addition, a novel method of heating a plasma was proposed, in which an isolated mass of ionized gas is subjected to a cyclically varying magnetic field. Arguments based on equipartition of energy show that the temperature of the plasma is thereby raised.

A paper by M. Rosenbluth (San Diego) was one of several theoretical studies concerned with the stability of the pinched discharge, one of which has been mentioned earlier. Rosenbluth treated the problem of a cylindrical discharge with axial magnetic field and conducting boundary, and gave conditions for stable operation. H. L. Jordan (Aachen) also discussed the stability of pinched discharges.

In the final session, the same topic was treated by R. J. Tayler (Harwell), who gave the results of 'normal mode' calculations of stability in pinched discharges. For a system in which the current is confined to the surface of a cylindrical column of gas, he showed that no stability is possible for the first-order 'mode' for any external magnetic field if the discharge tube has an insulating wall. With a conducting boundary of not too great a radius, image forces can remove the residual instability, so that complete stability is possible. For the more general case of a volume distribution of current the situation is complex, but complete stability is not very likely.

W. B. Thompson (Harwell) considered the transition between low-current discharges controlled by diffusion and the high-current pinched discharge. H. Margenau (New Haven) presented a paper on the conductivity of plasmas with respect to microwaves in which the distribution function was assumed to have one of several simple forms and was perturbed only slightly by the microwave field. He also reported work with D. C. Kelly on power absorption from microwaves at the cyclotron resonance by electrons of low energy in a discharge. From the half-width of the resonance curve the collision frequency could be deduced.

Two papers were presented by J. G. Linhart (Geneva) and D. C. de Packh (Washington) on the problems arising in the production of electron beams with neutralized space-charges first discussed by Bennett[1] and Budker[2]. In the first paper by Linhart the theory of the production of such beams was considered. In the second, read by A. C. Kolb, the possibility of additional focusing of electrons by external magnetic fields was taken into account, leading to a reduction in the stabilizing proton-core and to conditions which are rather easier to realize in practice.

Two general addresses remain to be mentioned. These were by Prof. V. Gori (Rome) and Dr. A. von Engel (Oxford), and took the form of tributes to the life and work of the late Prof. Giorgio Valle.

The success of the Venice meeting lay largely in the presentation, in many of the papers, of much really new material and in the evidence thus provided of intense activity on a wide front. The next conference of the series is to be held in Upsala in 1959.

W. R. S. Garton
R. Latham

[1] Bennett, W. H., *Phys. Rev.*, **45**, 890 (1934).
[2] Budker, G. J., *Cern Symposium Proc.*, **1**, 68 (1956).

DUTCH–NORWEGIAN JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

REPORT FOR 1955–56

THE Joint Establishment for Nuclear Energy Research (J.E.N.E.R.), situated near Oslo and operated jointly by the Norwegian Institutt for Atomenergi (IFA) and the Dutch Stichting Reactor Centrum Nederland (RCN) through a commission consisting of three Dutch and three Norwegian members, has recently issued its fifth annual report*, covering the period from July 1, 1955, to June 30, 1956.

The natural-uranium reactor, JEEP, which is moderated and cooled with heavy water and has now been in operation for nearly five years, is the main piece of research equipment at the Establishment. Its total energy release during the period under review was about 70 MW.-days, compared with 50 MW.-days for 1954–55. The reactor had a major shut-down during February 26–March 12, 1956, for the installation of a new heat-exchanger, the final stage in the introduction of a new cooling system. This heat-exchanger, which transfers the heat from heavy to ordinary water, has five times the surface area of the old exchanger, and the ordinary water is circulated from it through a cascade-type cooling tower to a reserve tank. With the new cooling system the reactor may be operated at a much higher power-level than previously, and, in addition, the operation is entirely independent of the prevailing weather conditions. The fuel elements were inspected twice, during August 1955 and March 1956, and the inside of the reactor tank once, during August 1955; their conditions were found to be satisfactory and no replacements were made.

During the year the number of shipments of radioisotopes from the Establishment totalled 614, only a small increase on the previous year's total of 579. The shipments were mainly to Norway, Sweden, Denmark and Holland. An additional 204 irradiations were made for use within the Establishment. Although the demand for radioisotopes is steadily increasing, no increase in production can be expected until the completion of the construction of the new buildings, for which plans have already been made. The report includes a list of the various isotopes produced, the number of shipments and their destinations, and the main fields of application.

New research equipment has been installed in both the metallurgy and physics laboratories, where a wide range of experimental work is being carried

* Fifth Annual Report, July 1955–June 1956, of the Dutch–Norwegian Joint Establishment for Nuclear Energy Research. Pp. iv+32. (Lillestrøm: Joint Establishment for Nuclear Energy Research, 1957.)

out. For casting uranium, a high-frequency (450 kc./s.) induction high-vacuum furnace supplying 22 kW. has been constructed, and metal specimens weighing 1–2 kgm. can now be melted and cast under a pressure of about 2×10^{-7} mm. of mercury. Since uranium exhibits dimensional instability, both on thermal cycling and under irradiation, a thermal cycling furnace has been built for the study of the behaviour of the metal under cycling conditions. The instability is known to be dependent upon the degree and type of preferred orientation, and a series of dilatometric experiments on preferred orientation in uranium containing 0·25 per cent chromium has been carried out. Additions to the equipment used for neutron diffraction work and for crystal structure studies included a Philips X-ray diffraction unit, a Geiger-counter diffractometer and several X-ray cameras, and studies have been made of hexamethylenetetramine, pentaerythritol, calcium hypophosphite, and mercury oxide. Other experiments conducted in the Physics Division have been concerned with the circular polarization of capture gamma-rays, and the gamma-rays emitted by fission fragments. The series of photo-nuclear reaction studies at Det Norske Radiumhospital using the betatron has been continued.

In the Chemistry Division, in addition to routine chemical and spectrographical analyses, the recovery of cæsium-137 from fission products by co-precipitation with ammonium aluminium sulphate is being investigated. The study of the chemistry of plutonium has continued, and a sixty-four channel pulse height analyser, constructed in the electronics workshop, is now being used for routine analysis of uranium and plutonium mixtures.

During the second half of the year most of the work at the Establishment was concerned directly or indirectly with the Halden boiling-water reactor project, which was referred to in the report for 1954–55 (see *Nature*, 178, 1220; 1956). In 1956 the project received the official approval of the Norwegian Parliament, and the work is now well advanced. The reactor will be financed and built under the auspices of the Institutt for Atomenergi, but the design and planning are to be carried out by the Establishment. Many of the mechanical components will be produced by Norwegian firms, and negotiations are stated to be in progress with the United Kingdom Atomic Energy Authority and with the United States Government for the supply of the uranium fuel and heavy water, respectively. The reactor will be fuelled by seven tons of uranium distributed in a hexagonal lattice with a maximum of 325 fuel elements. The amount of heavy water needed as moderator and coolant is 15 tons. Initially, ten cadmium control stations will be installed, but the design allows for an additional nine if required. Although the plant will eventually supply process steam to a nearby paper mill, this is merely intended as an inexpensive way of dissipating the liberated energy, and the plant should really be regarded as an experimental engineering plant with a high degree of flexibility in design, permitting considerable variation in many of the basic specifications. The detailed discussion of the Halden project in the annual report includes a simplified schematic diagram of the reactor and associated equipment.

In the final sections of the report details are given of the various reports and publications issued by the Establishment during the period under review; of the reactor courses given at the Establishment; of personnel and accounts; of the numerous scientific meetings and conferences at which the Establishment was represented; and of the thirty-seven guest scientists representing twelve different nations who worked at the Establishment during part or the whole of the period covered by the annual report.

THE BRISTOL MUSEUM

REPORT FOR 1956

THE annual report* of the City of Bristol Museum is, as one has come over the years to expect, a well-produced, readable and stimulating publication reflecting the activities of one of Britain's outstanding provincial museums. Putting first things first, it deals with the personnel of committee and staff, with changes of persons and of posts, with new recruits and with degrees awarded, winding up with a gracious recognition of long services rendered—retirements after 22, 22 and 26 years—a loyalty accorded and therefore clearly inspired. A novel post filled during the year is that of assistant curator in conservation, which called naturally for accommodation and equipment, a special laboratory and an iron treatment room. This is surely a realization of the best and most up-to-date in the museum tradition reflected in Dr. H. J. Plenderleith's recently published and remarkable text-book (see *Nature*, 179, 280; 1957).

In another field Bristol Museum continues to lead, namely, in its public education services, which achieve great things, not only among adults and school-children of the area, both in classes and in leisure-time societies and clubs, but also among museum men and educationists from elsewhere, who seek practical experience and inspiration to transplant to their own institutions. Work continues on the permanent exhibits, inevitably calling for improvement and re-identification as research adds to the general field of knowledge, and the fact that half the report is devoted to a list of accessions indicates both the lively outlook of the director and curators of Departments and the appeal the Museum exerts upon its supporters.

Temporary exhibitions, which do so much to enliven and attract, numbered no less than fifteen. Among the special features which have been continued with increasing success is the 'exhibit of the month', to which the city archivist has added quarterly exhibitions of Bristol playbills, concert notices, news-sheets of royal visits and so on, while the city librarian has provided material dealing with a local figure, the boy-poet Chatterton. The Museum finds a ready demand for its *Quarterly Bulletin* and for leaflets describing summer walks—which have an embarrassing success—and winter lectures. The list of conferences, together with their home ports, is a most impressive one. Yet, with all these varied offerings to a public seven days each week, the staff has time to serve on a wide range of local and national committees and to conduct research and to publish the results in scientific and learned periodicals of standing. This is a full report betokening, on the part of all concerned, a full and doubtless satisfying life.

D. A. ALLAN

* City and County of Bristol. The City Museum: Report of the Committee for the year ended 31 December 1956. Pp. 22+2 plates. (Bristol: City Museum, 1957.) n.p.

DEFENCE MECHANISM OF PLANTS AGAINST FUNGI

Fungistatic Properties of Apple Leaf Wax

MANY workers have reported the occurrence in plants of antifungal agents which may contribute towards the natural ability of the plants to resist infection by fungi. Gilliver[1] found that macerates of many plants could inhibit spore germination, while Topps and Wain[2] have recently substantiated the early findings of Brown that the intact leaves of some species of plants yield small quantities of water-soluble compounds possessing fungitoxic properties. Spencer, Topps and Wain[3] have also detected the presence, in exudates of the stem and root of *Vicia faba*, of an antifungal substance, phenolic in character, which, they suggest, is produced in response to a wounding stimulus. Buxton[4] has shown that some pea root exudates are active against *Fusarium oxysporum*, and Turner[5] has reported that the sap of seedling oat leaves contains an inhibitor of *Ophiobolus graminis*. Protocatechuic acid has been linked with the resistance to disease of onion varieties[6], while Virtanen and his co-workers[7] have isolated a fungitoxic compound, 2(3)-benzoxazoline, from cereal seedlings. Reports have also been made of the association of chlorogenic acid and phenolics with the disease resistance of varieties of potato, wheat and linseed.

The natural defensive mechanism of apple leaves and fruits has also received attention. Zschokke, as early as 1897, considered that any resistance of apple fruits to fungus infection was due to chemical substances and not to mechanical protection afforded by the cuticle. Later, Wiltshire and Johnstone reported from Long Ashton a correlation between the resistance of apple leaves and the toxicity of expressed sap to scab spores. Kirkham and Flood[8] at East Malling have recently shown that compounds of the chlorogenic acid type are involved in the natural protection of apple shoots from scab.

We have examined the leaf wax of apple and other species, since this may be expected to form the first barrier to infection. The waxy material was obtained by washing leaves with ether at room temperature. On extraction of the ether solutions with dilute alkali (1 per cent potassium hydroxide or 1 per cent sodium bicarbonate followed by 1 per cent potassium hydroxide solution) appreciable quantities of acidic materials were obtained. These were then separated into fractions preferentially soluble in ether ('ether-soluble acids') or water ('water-soluble acids'). The remaining waxy material was steam-distilled to give the volatile, non-acidic constituents, and the residual resin was fractionated by the addition of acetone to a concentrated ether solution to obtain the 'true wax' (acetone-insoluble) and 'oil' (acetone-soluble) components (see Table 1).

The apple leaf waxes and their constituents were examined for their ability to inhibit the germination of the conidia of mildew (*Podosphaera leucotricha*). Healthy detached leaves of the mildew-susceptible *MM* 104 apple rootstock were lightly sprayed with an ether solution, or dipped in a water solution, containing 0·075 per cent of the material under test. Provided the leaves were not too young, no damage resulted from the ether treatment; the amount of material deposited was of the order of 40 μgm./sq. cm. A small amount of wetter was added to the aqueous solutions to ensure adequate wetting of the leaves; the amount of acidic material left on the leaf tissue after drying was judged to be about 6–8 μgm./sq. cm. The leaves were then dusted with mildew conidia taken from infected rootstocks or orchard trees and, with their petioles immersed in water, were incubated for 48 hr. at 20° C. and relative humidity about 80 per cent. The spores were recovered from the leaves on cellulose acetate films[9], stained with 1 per cent aqueous safranin and examined for percentage germination (see Table 2).

Table 1. Composition of Apple Leaf Wax, 1957

	Variety	Per cent fresh weight of leaves: April 30	May 27	June 20	July 3	July 15
Total leaf wax	*W*	0·73	0·52	0·43	0·36	0·50
	C	0·51	0·30	0·47	—	—
Ether-soluble acids, bicarbonate extraction	*W*	*	*	*	0·01	0·03
	C	*	*	*	—	—
Water-soluble acids, bicarbonate extraction	*W*	*	*	*	0·02	0·12
	C	*	*	*	—	—
Ether-soluble acids, potash extraction	*W*	0·20	0·20	0·20	0·15	0·20
	C	0·17	0·13	0·23	—	—
Water-soluble acids, potash extraction	*W*	*	0·11	0·03	<0·01	0·01
	C	*	0·05	0·04	—	—
Volatile components	*W*	0·01	<0·01	nil	<0·01	<0·01
	C	0·01	nil	<0·01	—	—
Wax (acetone-insoluble)	*W*	0·02	0·03	0·03	0·04	0·04
	C	0·03	0·02	0·04	—	—
Oil (acetone-soluble)	*W*	0·11	0·08	0·09	0·07	0·08
	C	0·09	0·06	0·07	—	—

W, Worcester Pearmain; *C*, Cox's Orange Pippin; * not determined

The outstanding feature of the analytical results is the high proportion in the leaf waxes of materials extractable by dilute alkali. The ether-soluble acids obtained from the Worcester and Cox leaves collected in 1956 were subjected by Dr. C. G. Whiting to paper chromatography using a benzyl alcohol–isopropyl alcohol–tertiary butyl alcohol–formic acid–water mixture. The main acidic spot ($R_F = 0{\cdot}82$) showed some fluorescence which was rather stronger with

Table 2. Percentage Germination of Mildew Conidia on Leaves of *MM* 104 Apple Rootstocks treated with Fractions of Apple Leaf Wax, 1957

Total leaf wax	Variety	May 27	June 20	July 3	July 15
Total leaf wax	*W*	15	27	17	*
	C	30	20	—	—
Ether-soluble acids, bicarbonate extraction	*W*	*	*	14	10
	C	*	*	—	—
Water-soluble acids, bicarbonate extraction	*W*	*	*	56	46
	C	*	*	—	—
Ether-soluble acids, potash extraction	*W*	6	0	5	3
	C	2	3	—	—
Water-soluble acids, potash extraction	*W*	*	22	58	46
	C	*	64	—	—
Volatile components	*W*	*	*	21	20
	C	*	*	—	—
Wax (acetone-insoluble)	*W*	26	34	22	20
	C	45	32	—	—
Oil (acetone-soluble)	*W*	42	38	15	12
	C	38	36	—	—
Control, untreated		76	76	57	
Control, water + wetter		*	66	54	
Control, ether		66	64	55	

W, Worcester Pearmain; *C*, Cox's Orange Pippin; * not determined.

ammonia and gave positive reactions with the following reagents: ferric chloride (reddish-purple, brown on exposure to ammonia), ferric chloride–potassium ferricyanide (strong blue colour), alkaline potassium permanganate (yellow colour), diazotized *p*-nitraniline (strong reaction, orange) and ammoniacal silver nitrate (reduced). These properties are very similar to those of the phenolic compound detected in exudates of *Vicia faba* by Spencer, Topps and Wain.

Elution of the Cox ether-soluble acids from a silica gel column with chloroform and chloroform–tertiary butyl alcohol mixtures gave two main components: a phenolic material and a strongly acidic substance which gave a bright blue fluorescence with ammonia, reduced silver nitrate weakly and gave no reaction with diazotized *p*-nitraniline. A small amount of the acidic material was recovered in crystalline form melting at 123–127° C.

Measurements of leaf surface area permitted an assessment to be made of the intensity of wax formation on the leaves. Young leaves showed about 50 μgm. of waxy material per sq. cm., with an indication of a heavier deposition on the Worcester than on the Cox leaves. Later in the season lower fluctuating values were obtained.

The biological results show that the Worcester and Cox leaf waxes, and some of their fractions, when sprayed on to mildew-susceptible leaves bring about a reduction in the germination of apple mildew conidia. The most striking fungistatic effect is shown by the ether-soluble acidic material extracted from the leaf waxes by dilute potash. The toxicity of this fraction was also shown in tests with *Botrytis fabae*; deposits of the acids on broad bean leaves entirely suppressed the formation of fungus lesions.

It seems reasonable to suppose that the ether-soluble acidic fraction, which occurs in high proportion (about 40 per cent) in the wax, plays some part in the defensive mechanism of the apple leaf. The water-soluble acidic fraction, which is probably an exudate from within the leaf, may also contribute to the fungistatic property of the wax. Fractionations of the leaf waxes of broad bean, dwarf bean, pea, tomato, pear, cabbage, laurel and grass and of the fruit waxes of apple, tomato and gooseberry have shown that these also contain appreciable, although varying, quantities of ether-soluble acidic materials.

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Solubilization of Copper by Leaves and Water-soluble Acids from Leaf Wax

Barker and Gimingham[1] in 1911 put forward three possible mechanisms of the fungicidal action of Bordeaux mixture on plant surfaces. One postulated that solubilization of copper was effected by secretions of the fungus, and another, that the host plant itself played a part in the liberation of copper from the insoluble spray deposit. These possibilities were examined by later workers, notably McCallan and Wilcoxon[2] and Wain and Wilkinson[3], and the theory involving the action of secretions of the fungus received support. In their examination of the effect of the host plant, Wain and Wilkinson found that runner bean leaves released copper from Bordeaux mixture, but they considered their experiments suspect because of interference from exuded sap and bacterial contamination. Curtis[4] has shown that the guttation fluids of plants solubilize copper from Bordeaux mixture, while Yarwood[5] has concluded that the plant may enhance the effectiveness of this fungicide.

Table 1. Copper dissolved from Bordeaux and Burgundy Deposits by Leaves

Leaf	Copper dissolved p.p.m. Bordeaux	Burgundy
Apple, Cox's Orange Pippin	7·9	—
Apple, Worcester Pearmain	6·9	1·3, 1·9, 3·8
Broad bean	2·2	3·3, 4·7, 5·5, 6·0, 9·4
Laurel	3·8, 2·3	2·7, 1·9, 1·6
Potato	1·9	5·7, 6·2, 3·7, 5·7
Tomato	—	1·8
Control, deposits on glass	0·12–0·14	0·24–0·36

We have determined the solubilization of copper from dry deposits of 10 : 12·5 : 100 Bordeaux mixture and 10 : 11·4 : 100 Burgundy mixture on different leaves. The upper surfaces of healthy, uninjured leaves of area 10–20 sq. cm. were sprayed with the fungicides to the point of run-off and allowed to dry overnight. The leaves were then detached and their petioles immersed in paraffin wax to prevent sap exudation and to maintain leaf turgidity. Each leaf was placed in a Petri dish, weighted with a glass triangle, 30 ml. of glass-distilled water were added, and the dish was gently agitated for 17 hr. at 25° C. The liquid was centrifuged to remove any solids in suspension and its copper content determined[6] (see Table 1).

Other tests were made using the water-soluble acids separated from leaf waxes as described in the previous section. Burgundy mixture was sprayed on to Petri dishes and allowed to dry. Water solutions of the acids (concentrations 0·02–0·10 per cent: *p*H 4·3–3·4) were added and the dishes were agitated as before. The liquids were recovered free from suspended matter and analysed for copper content (see Table 2).

An excess of insoluble fungicide was present at the end of each test, and on no occasion did bacterial contamination occur. On some occasions minor leaf damage resulted in abnormally high values for dissolved copper and these are not reported. Comparable tests with the leaves and water-soluble acids showed that only slight solubilization of copper occurred from deposits of cupric oxide. No solubil-

Table 2. Copper dissolved from Burgundy Deposit by Water-soluble Acids separated from Leaf Waxes

Water-soluble acids	Copper dissolved p.p.m.
Cox apple wax, potash extraction	5·5, 4·1, 3·8, 4·2
Worcester apple wax, potash extraction	5·6, 10·5, 2·8, 3·3
Worcester apple wax, bicarbonate extraction	10·2
Laurel wax, potash extraction	9·1
Control, water alone	0·3

izing effect was obtained in tests using the ether-soluble acidic fraction of apple or laurel leaf wax.

The results show that leaves and the water-soluble acids associated with leaf waxes are capable of solubilizing copper from Bordeaux or Burgundy spray deposits. These fungicides exert their toxic effect by virtue of the liberation of copper in solution. Although solubilization of copper is known to result from the action of spore suspensions containing a million or so spores per ml., it is difficult to believe that the exudates of spores occurring naturally on leaf surfaces can exert a significant effect. The conclusion is reached that the host plant, through the influence of acidic material associated with its wax, plays the primary part in bringing about the fungitoxic action of Bordeaux or Burgundy mixture.

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Sorption of Copper from Burgundy Mixture by Leaves

Large *et al.*[1] found that when Bordeaux mixture deposits had been present on potato leaves for three weeks a significant amount of copper was retained by the leaves after exhaustive acid washing, although no sorption could be detected from fresh deposits. Smith *et al.*[2] and Hammar[3] have also shown that part of a copper spray deposit is not removed by acid washing. This matter has been re-examined, since a significant degree of sorption of copper by leaves may reduce the fungitoxicity of the spray deposit.

Burgundy mixtures (prepared from equimolar solutions of copper sulphate and sodium carbonate) of 0·25 and 1·25 per cent copper content were placed in 5-μl. droplets, each containing 8–10 or 40–50 μgm. copper, on the under surface of broad bean leaves. When the deposits had dried the leaves were removed from the plant and immersed, with gentle agitation, in 3 *N* hydrochloric acid for 0·5, 1 or 2 min. and in 0·1 *N* hydrochloric acid for 1, 2 or 5 min. The leaves were then well washed with water before acid digestion and copper analysis[4].

The copper remaining on the leaf after these washing processes amounted to approximately 0·03 μgm. per droplet and was uninfluenced by the period the deposit had remained on the leaf (up to 3 weeks) or by the concentration of Burgundy mixture used. The copper sorbed from total deposits of 150–200 and 750–1,000 μgm. copper per leaf was less than the naturally occurring copper present in the leaf.

Table 1. Copper sorbed from Burgundy Mixture by Broad Bean Leaves

Leaf surface	Washing procedure	μgm. Copper sorbed/droplet
Upper	0·1 *N* hydrochloric acid, 1 min.	0·16
	0·1 *N* hydrochloric acid, 5 min.	0·10
Under	3 *N* hydrochloric acid, 30 sec.	0·03, 0·02, 0·02, 0·05
Under	0·1 *N* hydrochloric acid, 1 min.	0·07, 0·08, 0·09

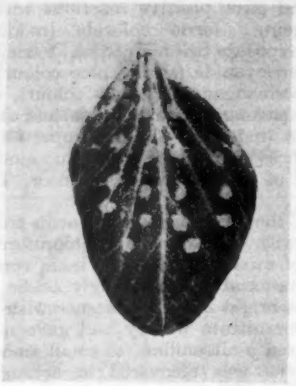

Fig. 1. Under surface of broad bean leaf showing inhibition of *B. fabae* lesions by Burgundy mixture (0·00012 per cent copper) (0·006 ± 0·002 μgm. copper/droplet)

A confirmatory experiment was carried out using copper-64. Irradiated copper foil was dissolved in sulphuric acid, the sulphate was precipitated in alcohol, dissolved in water and added to equimolar sodium carbonate to give a copper concentration of 0·25 per cent. Droplets of 5 μl., each containing 8–10 μgm. copper, were applied to bean leaves. The copper sorbed after the dried deposit had been on the leaf for 4 hr. was determined by radio-assay of acid digests (see Table 1).

The results confirm the values obtained by chemical analysis; the small amount of copper sorbed resisted the action of 3 *N* hydrochloric acid. An equivalent Burgundy deposit on glass was completely removed in 20 sec. by 0·1 *N* hydrochloric acid. Autoradiographs of the acid-washed leaves showed spots of the same size as the applied deposits, indicating that copper was not redistributed on the leaf by the acid washing. The upper surface of the leaf showed a similar capacity for sorption of copper.

To determine whether the sorbed copper was fungicidally active, a modification[5] of Morgan's bioassay technique[6] was used. Spores of *Botrytis fabae* Sardiña were dusted on to the under surface of bean leaves;

Fig. 2. Under surface of broad bean leaf. Deposits of Burgundy mixture (0·25 per cent copper) washed off with 3 *N* hydrochloric acid for 30 sec.—no inhibition of lesion formation. (0·02 μgm. copper/droplet remaining)

the spore density on the leaf was 500–1,500 spores/sq. mm. After incubation in a water-saturated atmosphere at 21° C. for 16 hr. the surface of the leaf was completely covered by lesions. On treating leaves with 5-μl. droplets of Burgundy mixture (0·25 per cent copper), lesion-free areas, of dimensions identical with those of the deposits, were produced. The most dilute Burgundy mixture (0·00012 per cent copper) that would inhibit lesion formation contained 0·006 ± 0·002 μgm. copper per 5 μl. droplet (Fig. 1).

Leaves that had been treated with Burgundy mixture and acid washed as described above were also subjected to the fungus infection test. Without exception, lesions formed over the whole leaf surface (Fig. 2). No fungitoxic action of the sorbed copper could be detected although it was present on the leaf in amounts up to fifteen times greater than the minimum giving a response in the bioassay test.

The results show that a small, but significant, amount of copper is sorbed from a Burgundy deposit by bean leaves and that this copper is fungicidally inactive. The experimental evidence suggests that the copper is adsorbed on the surface rather than absorbed into the leaf and that the sorption occurs while the fungicide deposit is drying.

We are indebted to Mr. C. P. Lloyd-Jones for carrying out the radioassays and to Mr. N. G. Morgan for advice on the bioassay technique.

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ADDITIONAL PURINE COMPOUNDS IN THE VENOM OF THE TIGER SNAKE (*NOTECHIS SCUTATUS*)

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FISCHER and Dörfel[1], and Doery[2], have identified adenosine, adenosine 3′-phosphate and a guanine compound in snake venoms. In this communication, which supplements the earlier report[2], the guanine compound and two additional purines are identified in the venom of *Notechis scutatus* as guanosine, inosine and hypoxanthine, respectively.

The preparation of the venom and the paper chromatography techniques in use were the same as those described earlier. In the course of some chemical fractionations of the venom of *Notechis scutatus*, an ultra-filtrate of the aqueous solution of the venom was prepared, using a membrane similar to that described by Wilson and Holiday[3]. The ultra-filtrate was dialysed against distilled water and the dialysate dried from the frozen state. Solutions of ultra-filtrate dialysate were applied to Whatman No. 1 filter paper and run in *n*-butanol–water for 16–60 hr. at room temperature (20–24° C.). Purine spots were eluted with distilled water, dried from the frozen state and aliquots treated as follows: (*a*) portions were chromatographed as above; (*b*) further portions, dissolved in 0·2 *N* hydrochloric acid and 1 *N* sodium hydroxide, were examined in a Unicam spectrophotometer between 220 and 300 mμ (Table 1); (*c*) the remaining portions were hydrolysed in 1 *N* hydrochloric acid at 100° C. for 1 hr., and the products dried. The hydrolysed eluates were examined both chromatographically in *n*-butanol–water or isopropanol–hydrochloric acid, and in the spectrophotometer as above (Table 1). Nucleic acid hydrolysed in 1 *N* hydrochloric acid for 1 hr. at 100° C. provided markers for adenine and guanine.

By longer development in *n*-butanol–water, two zones, each of which was previously considered to be homogeneous, are now shown to be composite.

The five purine compounds are identified in ultra-filtrate dialysate (Fig. 1) in order from the origin as: (1) adenosine 3′-phosphate; (2) guanosine; (3) inosine; (4) adenosine; (5) hypoxanthine; (2) and (3) being resolved completely only after 60-hr. development. Chromatography of the hydrolysates of the eluted compounds (1), (2) and (4) (Fig. 2) identifies the base of compounds (1) and (4) as adenine and (2) as guanine, supporting the conclusion that compounds (1), (2) and (4) are adenosine 3′-phosphate, guanosine and adenosine, respectively. Finally, the hydrolysate of eluted compound (3) and the eluate of compound (5), both before and after hydrolysis, have the same R_F value as hypoxanthine (Fig. 3), which confirms the identity of compounds (3) and (5) as inosine and hypoxanthine, respectively.

The absorption data on eluates from chromatograms (Table 1) further support the identification of guanosine, inosine and hypoxanthine.

The ultra-filtrate dialysate, a protein-free source of all the purine compounds in the venom, provided a concentration of those compounds 2–10 times that found in the previous fractions[2], and was more readily available for the present study. In the earlier investigation[2], three purine compounds were separated with the solvent *n*-butanol–water, and

Table 1. Wave-lengths of Maximum and Minimum Absorption of Eluates

Assumed identity of eluate	Solvent	mμ	
		Max.	Min.
Guanosine	0·2 *N* HCl	253·5	227
Inosine	0·2 *N* HCl	250	221
	1·0 *N* NaOH	254	229
Hypoxanthine	0·2 *N* HCl	247	216
	1·0 *N* NaOH	262	232·5
Inosine hydrolysed	0·2 *N* HCl	249	216·5
	1·0 *N* NaOH	263	235
Hypoxanthine hydrolysed	0·2 *N* HCl	246·5	215
	1·0 *N* NaOH	262·5	233·5

Fig. 1. Solvent: 86 per cent (v/v) aq. *n*-butanol (ref. 4); descending. (*a*) hypoxanthine; (*b*) adenosine; (*c*) ultra-filtrate dialysate; (*d*) inosine; (*e*) guanosine; (*f*) adenosine 3′-phosphate

identified by appropriate markers by characteristic fluorescence and absorption maxima as adenosine, adenosine 3′-phosphate and a guanine compound. Protein material remained at the origin together with adenosine 3′-phosphate. Further, using the solvent sodium dihydrogen phosphate–isoamyl alcohol, three purine compounds were separated from protein material, and two of these were identified as adenosine and adenosine 3′-phosphate. When an eluate of the third compound showed an absorption maximum near 249 mμ, it was assumed to be the guanine compound. This has now been identified as inosine, which alone of the five compounds moves as a single component in sodium dihydrogen phosphate–isoamyl alcohol. The zones of adenosine and hypoxanthine overlap, as do those of adenosine 3′-phosphate and guanosine. Thus, the unsuitability of sodium dihydrogen phosphate–isoamyl alcohol as a solvent for the separation of the five compounds, which are completely resolved by longer development in *n*-butanol–water, is now evident.

Subsequent to the above examination, an extract of the venom of eight tiger snakes 'milked' directly into 3 per cent perchloric acid was examined. The supernatant and washings from the resulting protein precipitate were neutralized with 2 *N* potassium hydroxide, and the insoluble potassium perchlorate removed by centrifuging. The supernatant was dried from the frozen state and chromatographed in *n*-butanol–water. Adenosine, adenosine 3′-phosphate and guanosine were clearly identified, a slight trace only of inosine was detected, while hypoxanthine was absent.

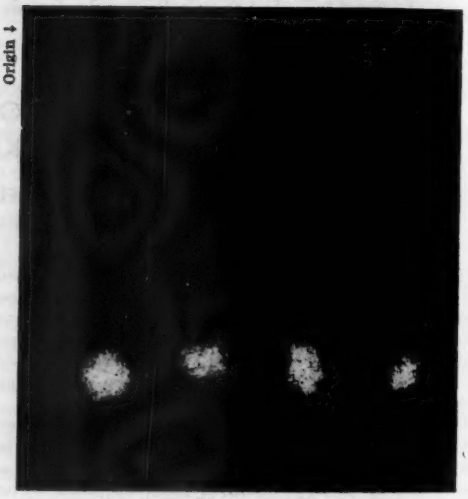

Fig. 3. Solvent: 86 per cent (v/v) aq. *n*-butanol (ref. 4); descending. (*a*) eluate compound (5); (*b*) hydrolysate eluate compound (5); (*c*) hypoxanthine; (*d*) hydrolysate eluate compound (3)

Fig. 2. Solvent: isopropanol (65 per cent v/v)–water–hydrochloric acid 2.0N (ref. 5): ascending. (*a*)–(*d*) hydrolysates of (*a*) eluate compound (4); (*b*) eluate compound (2); (*c*) nucleic acid; (*d*) eluate compound (1)

The venom in which inosine and hypoxanthine were identified was a portion of a pooled batch constituting some thousands of venom 'milkings'. While these two substances may have arisen from adenosine by enzymic action during protracted drying of the venom, conclusive proof of this point is beyond the scope of this investigation.

The earlier arguments favouring the existence of the three purine compounds as natural constituents of fresh venom are now substantiated in the identification of adenosine, adenosine 3′-phosphate and guanosine in a perchloric acid extract of freshly ejected venom.

I thank Miss F. Bates for skilled assistance with the chromatography, Mr. J. Thayer for assistance with the ultra-filtration, and Prof. R. K. Morton for his continued interest. I am indebted to the Director of the Healesville Sir Colin Mackenzie Sanctuary, Mr. Gasking, and Mr. Tanner for the supply of fresh venom.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Supposed Asexual Reproduction in Trilobites

THE study of the newly discovered recent member of the Cambro-Silurian mollusc group Monoplacophora has caused me to extend investigations also to animals other than molluscs of the early Cambrian fauna. Then, I was struck by the appearance of some Olenellid Trilobites figured by Walcott[1], showing additional segments behind what usually forms the long spine of the last segment (Fig. 1).

These illustrations strongly indicate that asexual budding from the posterior end of the animal was taking place at the time of fossilization, in almost the same manner as is often found in syllid Polychaetes of to-day (Fig. 2—from Malaquin[2]). Although Walcott's figures were published in 1910, explanations of them have been very scarce. Störmer[3] and Snodgrass[4] have redrawn them (Figs. 10 and 1 respectively) without comments, except that Störmer, following usual practice, terms the hindmost segments "segments abortifs".

It would appear more straightforward to suppose these posterior segments to be new ones formed by budding off from the posterior end of the adult *Olenellus*, as explained below.

(1) So far as I have been able to make out, the 'abortive segments' are found exclusively on fully grown specimens. Smaller ones have the same (or in quite juvenile ones fewer) segments as the pre-spinal ones in the adult, but never those extra ones which in later life should become 'abortive'.

(2) In the animal shown in Fig. 1,*A* and *B* the length of each segment is constant from the first one behind the head and including the spine-bearing one, whereas the width of the median part decreases slightly. Behind the spine, all segments are shorter but again uniform in length, whereas the first ones are slightly broader than the last pre-spinal ones (verified on new photographs obtained from the U.S. National Museum by the courtesy of Dr. E. L. Yochelson).

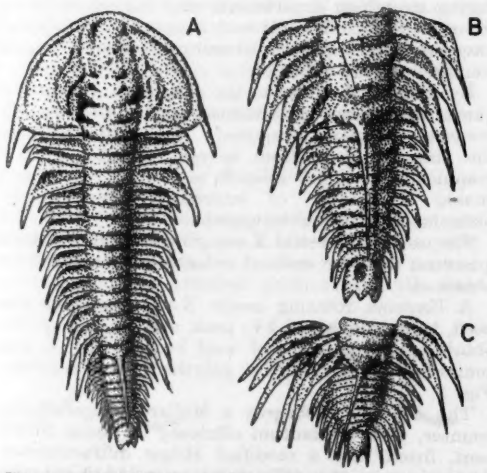

Fig. 1. The trilobite *Olenellus vermontana* (Hall) showing 'abortive segments' behind the normal ones. *B*, an enlarged drawing of the hind part of the specimen shown in *A*; *C* shows another specimen. (From Walcott, redrawn)

Fig. 2. The Polychaete *Autolytus edwardsi* De St.-J. Posterior part of the body with four rudiments of new animals of different ages budding off. (From Malaquin, redrawn)

(3) The specimen shown in Fig. 1,*C* has the same number of 'abortive' segments as shown in Fig. 1,*A* and *B*, although each one is still shorter. The shortness could be due to one of two causes. Either the segments are in a stage of growth where they have not yet attained full length, as here supposed, or the fossil is from a cast skin where the posterior segments have been so pressed into each other as to appear shortened. As, however, the shortened segments are definitely the post-spinal ones, the anterior ones being unaffected, the latter explanation seems scarcely probable.

(4) The telson forming the posterior end of the 'abortive segments' has a small median spine which could easily grow into a new large spine occupying the usual terminal position in the new animal.

(5) The size of the pleural lobes decreases suddenly at exactly the same place where the segmental length is reduced.

(6) Quite a number of specimens of different species within the family Olenellidae are known to possess 2–6 extra segments behind the spine-bearing one. These cases are supposed here to show the first rudiments of new animals appearing without having reached their final number of segments. Conversely, in the very few cases known where large numbers of 'abortive' segments have been found (up to twenty-nine such ones have been recorded in *Paedeumias robsonensis* Burling[5], here quoted from Raw[6]) these are not all the same size and are partly broken off, indicating that in this case there may have been several more and less-grown rudiments of new animals placed after each other at the posterior end of the animal, in the same way as is often seen in certain recent syllid Annelids (Figs. 2 and 3,*F*). In such cases, it cannot be expected that the number

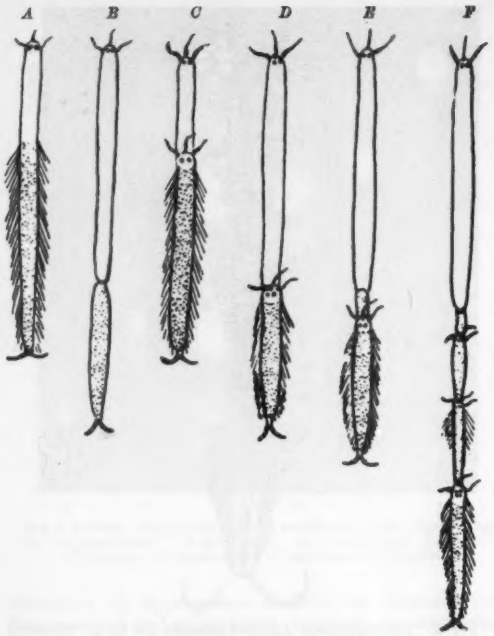

Fig. 3. Diagram of different modes of reproduction in syllid Polychaetes. *B–F*, different types of asexual budding. (From Malaquin, redrawn)

of extra segments falls within that usual to the fossils of the species in question.

(7) Clearly, *Olenellus* is able to develop through larval stages of typical shape, as appears also from Walcott's publication, but I have not seen any record of small specimens of the type on which has been based the generic name *Mesonacis*. As, however, Walcott[1] states that the pre-spinal segments are of *Olenellus* type, but the post-spinal ones of the *Mesonacis* type, and as he makes similar statements concerning the small extra segments in *Paedeumias transitans*, I should be much obliged to palæontologists if they will inform me whether larval or very young specimens of *Mesonacis* type are known. If not, the possibility would exist that *Mesonacis* represents specimens of the sexual, *Olenellus* and *Paedeumias* the asexual generation of different species with metagenesis.

(8) No rudiment of a head has ever been recorded to be intercalated between the spine-bearing segment and the following ones. Thus, as in several recent Polychaetes, the head would seem to have been formed after liberation of the new animal—or at least to have become chitinized after that time. Thus, in fossils, such a head should appear rather suddenly as a broad rudiment which eventually acquired normal shape, whereas specimens developing from larvæ should have narrower heads, shaped much more like those known from, say, *Agnostus*. In the description of *Wanneria walcottanus* (Wanner), Walcott[1] (his Pl. 30, Figs. 3–4) mentions that small and broad cephali exist. These could possibly be taken to have another origin than the narrower ones which certainly arise from growing larvæ.

It may be stressed that the suggestion of asexual propagation in Trilobites cannot hold good except for those forms still missing a true pygidium, that is, it is restricted to the Olenellids. Probably, a well-developed pygidium would constitute an insurmountable difficulty to asexual propagation as here described. The phylogenetical significance of the above suggestions would be in showing that the oldest known family of the Trilobites, the Olenellids, appears to share with primitive Polychaetes a most interesting biological character hitherto unknown in Arthropods.

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Rapid Observation of Phase Transformations in Fibrous Proteins using an X-Ray Diffractometer

Many naturally occurring fibrous materials possess X-ray diffraction patterns with few diffuse and ill-defined spots which defy precise analysis. Nevertheless, phase transitions involving such materials have been extensively studied and a great deal is known about them. Wool keratin, being of great technological importance, has been the subject of many investigations[1]. Of particular interest in the molecular biology of wool keratin are the time-dependent parameters of creep and relaxation and their relation to the stable α and β phases[2]. Little is known of the molecular changes involved during the simple process of stretching a fibre, and the interpretative difficulties are formidable if we must accept the coiled helical system (α) and a simple planar system (β)[3] as the two stable states in the reversible $\alpha \rightleftharpoons \beta$ transformation.

Rapid observation of the X-ray diffraction image during stretching experiments may help to reconcile the difficulties. To this end a number of workers[4] have suggested apparatus whereby diffraction patterns could be quickly observed.

By limiting the data to the equatorial direction, a quick record may be obtained which is sufficiently accurate for many purposes. The method reduces the time required from several minutes (photographically) to a few seconds and when refined will enable a number of interesting time-transient phenomena to be investigated.

The use of a powerful X-ray generator and sensitive quantum detector enabled satisfactory results to be obtained.

A Raymax rotating anode X-ray generator was used, being run at 60 kV. peak and 60 m.amp. for obtaining the patterns of wool keratin, Fig. 1, and somewhat lower for the polythene and cellulose, Fig. 2.

The detector used was a Mullard Geiger–Müller counter, with a quantum efficiency of about 50 per cent, fitted into a modified Hilger diffractometer. Alterations to the diffractometer included reducing the time constant (*RC*) of the integrating circuit to 0·1 sec. and the addition of an auxiliary drive system

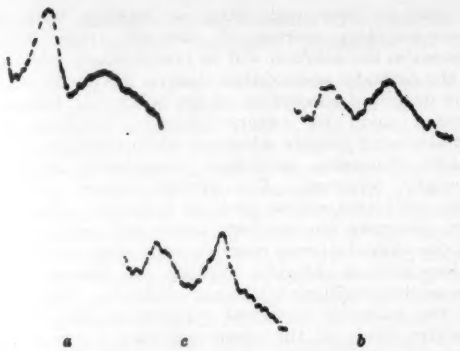

Fig. 1. Equatorial traverse ($5° < 2\theta < 40°$) showing the phase transformation in wool keratin, each diagram being recorded in five seconds. (*a*) Cleaned and Soxhletted α Lincoln wool keratin showing the strong composite reflexion about 9·8 A. and the partly oriented halo; (*b*) Extended 50 per cent in steam, dried and the diffraction pattern obtained within 90 seconds. The group about 9·8 A. is reduced and the characteristic β reflexion about 4·65 A. is quite apparent; (*c*) Further extension to about 75 per cent and the record obtained within four minutes. This is a well-formed β diagram with a strong reflexion about 4·65 A.

to permit scanning at the rate of 2π radians of 2θ per minute.

The outputs from the integrating circuits of both monitor and detector were fed to the amplifier circuits of a Cossor d.c. oscilloscope fitted with a long-persistence cathode-ray tube (Type 89*L*). *x*-Axis shift was obtained from a potentiometer directly coupled to the scanning arm.

Using this device, an image of the pattern was continuously observable on the screen and a fresh pattern, taking five seconds, was presented once every ten seconds. Typical of these records are those shown in Figs. 1 and 2.

An expression for the accuracy of observations with a system like this is given by

$$V\sqrt{NT} = 100$$

where V is coefficient of variation, N is mean counting-rate, T is total time of the scan. N is limited by durability and fatigue in the X-ray generator; but the rotating anode tube used enables N to be an order of magnitude greater than with a stationary anode type. A further reduction in the time could perhaps be obtained using a pulse technique[5] as in radiographic apparatus.

Equilibrium of the detector response (to within σ) occurs in a time

$$t = \frac{RC}{2} \ln (2NRC)$$

which under the experimental conditions and $N \simeq 1{,}000$ gives $t \simeq 0{\cdot}265$ sec.[5]. This is a little too long to yield an accurate line shape, as is seen by the marked asymmetry in the cellulose profiles; but the time constant could not easily be reduced below 0·1 sec. due to the use of a self-rectifying (50 Herz) tube.

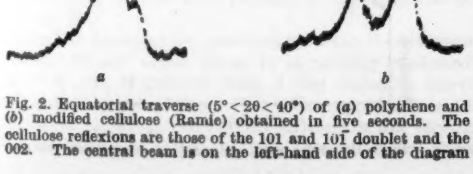

Fig. 2. Equatorial traverse ($5° < 2\theta < 40°$) of (*a*) polythene and (*b*) modified cellulose (Ramie) obtained in five seconds. The cellulose reflexions are those of the 101 and $10\bar{1}$ doublet and the 002. The central beam is on the left-hand side of the diagram

The true profile $\psi(t)$ may be obtained from the observed profile $\theta(t)$ by using the relationship

$$\psi(t) = \dot{\theta}(t)\ RC + \theta(t)$$

Theoretically, it should be possible to reconstruct a badly distorted curve; but the accuracy of such a procedure may not be high. Difficulties are involved in measuring the gradients and ordinates accurately and the inherent variation in the Poissonian input adds further errors.

Figs. 1 and 2 show in general the scope of the technique and its use for rapid diagnosis.

Fig. 1 is a simple stretching experiment carried out on a bundle of Lincoln wool keratin. The aim was to achieve a rapid phase transition; but practical manipulative difficulties introduced time limitations.

By comparing these patterns with those obtained in a more prolonged diffractometric investigation it appears probable that the transients involved in the α–β transformation in steam must occur in times less than those between the end-points of this experiment.

A process of ballistic extension (without rupture) might enable more rapid extensions to be achieved as the time taken to secure the diffraction data is not now the limiting factor in this type of experiment.

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A Unified Theory of the Mechanism of Inhibition of Corrosion of Iron in Acid and Neutral Media based on the Electrocapillary Behaviour of Ions

An attempt has been made to develop a single theory to explain the inhibition of corrosion of iron in both neutral and acid media on the basis of the electrical affinity of the metal/solution interface towards ions or neutral molecules present in the solution.

At a metal/solution interface there exists an electrical double layer the nature and composition of which depend upon the nature of the metal, the ions present in the solution and the potential difference existing between the metal and the solution. Let us examine the behaviour of this double layer on the basis of the electrocapillary phenomenon. *A C B* (Fig. 1) represents an electrocapillary curve of mercury for cations and anions such as Na^+, K^+ and Cl', SO_4'', NO_3' respectively. *C* represents the electrocapillary maximum. In the presence of cations or anions which are preferentially adsorbed, that is, capillary active, the e.c.m. is depressed and also shifted. A capillary active anion displaces the ascending portion (positive limb) and the maximum of the curve towards the right (*DC'B*), showing that at potentials positive to the e.c.m., this type of ion has a greater affinity for the metal surface than

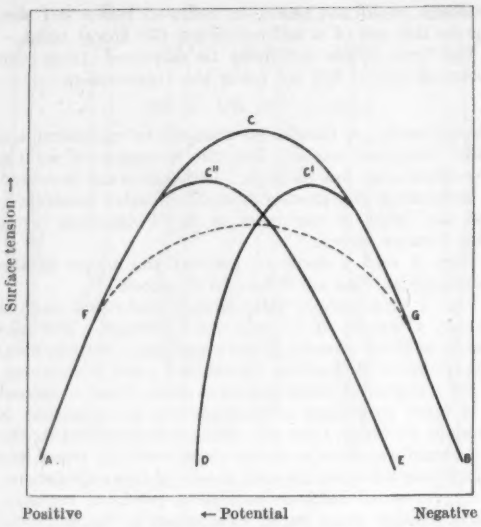

Fig. 1. Electrocapillarity curves for mercury in various solutions (schematic)

normal anions. Capillary active cations displace the descending limb towards the left ($AC''E$). Neutral molecules depress the upper portion of the curve (Fig. 1, FG).

Most of the experimental data on the electrocapillary effect refer to mercury the e.c.m. of which in the presence of inactive ions is about $-0{\cdot}2$ V. (H scale). Electrocapillary curves for liquid metals such as gallium and mercury amalgams and solid metals such as platinum and zinc have been reported to be similar in nature to those of mercury but with different values of the e.c.m. Ayazyan has recently reported a value of about $-0{\cdot}37$ V. for iron in sulphuric acid ($0{\cdot}001$ N) from the study of double-layer capacity at different electrode potentials[1].

When a specimen of mild steel bearing its air-formed oxide film is immersed in aqueous solution, the potential at the metal/solution interface is not uniform, the surface being divided into local cathodic and anodic areas. The oxide-covered portions of the surface are in the main cathodic, strained and defective areas in this oxide film forming anodic areas. The cathodic reaction is, in general, either the conversion of oxygen into hydroxyl ion or liberation of hydrogen, depending upon the pH and dissolved oxygen content of the solution. Evans and Hoar[2] have distinguished these zones in a corroding specimen and have measured their potentials in different electrolytes. The cathodic areas are always at a more positive potential than the anodic areas (see schematic cathodic and anodic polarization curves, Fig. 2). Approximate potentials existing at anodic and cathodic areas are indicated by the potentials given respectively by freely rusting iron ($-0{\cdot}5$ V.) and inhibited or passivated iron ($0{\cdot}0$ V.).

Let us now consider the behaviour of the metal/solution interface when the mild steel is immersed in a neutral medium containing electrolytes. If the value of e.c.m. of iron be assumed to be in the neighbourhood of $-0{\cdot}37$ V., then since the potential of the anodic areas is in the region of $-0{\cdot}4$ to $-0{\cdot}5$ V. and that of the cathodes is relatively more positive, it may be presumed, from an analogy with the electrocapillary curves of mercury, that anions present in the solution will be preferentially adsorbed in the cathodic areas rather than on the anodic areas. The degree of adsorption of the anion will, however, depend upon its nature—chloride, sulphate and nitrate being weakly adsorbed while capillary active anions (benzoate, salicylate, cinnamate) are more strongly adsorbed. The present theory requires that inhibitive anions such as benzoate, phosphate and chromate are capillary active and are adsorbed on the cathodic areas more strongly than are normal anions such as chloride, sulphate and nitrate, which are neither capillary active nor inhibitive. The value of the cathodic potential relative to that of the positive limb of the electrocapillary curve should determine the efficiency of adsorption. It may be noted that the greater adsorption of chromate, phosphate and benzoate ions relative to that of chloride on the surface of magnetite suspensions has been reported by Anderson[3] from electrophoretic zeta-potential measurements.

The theory further requires that the adsorption of the capillary active ions at the cathode should interfere with the cathodic depolarization by oxygen, this in turn diminishing the rate of dissolution of iron at the anode. The limited concentration of dissolved oxygen present in the solution can therefore oxidize the iron before it can enter solution from the anodic areas, thus completing the passivation. Rozenfeld and Akimov[4] have shown that chromate can cause cathodic polarization.

In neutral solution, therefore, if the postulated mechanism is correct, anions such as phosphate, benzoate, chromate, are primarily cathodic inhibitors, though the oxidizing anions chromate and nitrite can additionally produce anodic polarization. In con-

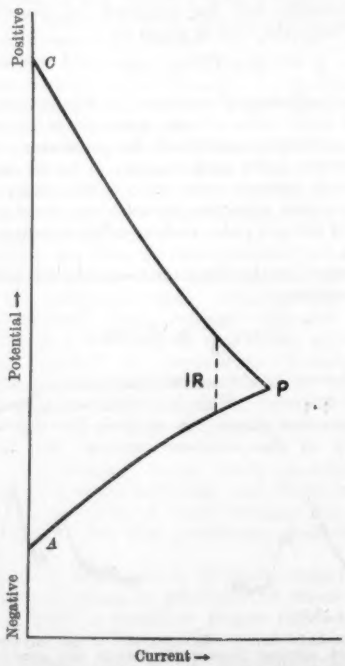

Fig. 2. Cathodic and anodic polarization curves (schematic)

firmation of this, the non-oxidizing inhibitors have been found to give 'corroding' potentials in the absence of oxygen[5].

In the case of iron in contact with acid, the air-formed oxide film is absent, and the potential of the cathodic areas approaches that of the anodic areas. The potential of the major portion of the surface (anodic) will remain at values more negative than the e.c.m. Capillary active cations such as alkyl ammonium ions and other basic nitrogen-containing cations will be preferentially adsorbed on the anodic areas reducing anodic dissolution. Non-ionic capillary active compounds such as thiourea depress the electrocapillary curve, flattening it near the e.c.m.[6], indicating that this type of inhibitor could be absorbed both on the anodic and cathodic areas. Hoar and Holliday[7] and Ride[8] have reported from their polarization studies of acid inhibitors that quinolines and aliphatic amines behave mainly as anodic inhibitors while thioureas polarize both the anodes and cathodes.

The above tentative mechanism can explain some of the facts known about inhibition. Experimental investigations will be undertaken to test this hypothesis. It will also be interesting to correlate the capillary active and inhibitive properties of the ion with their internal structure.

Many investigators have discussed the function of adsorption to explain corrosion inhibition, but I am not aware of any previous treatment of corrosion inhibition in terms of electrocapillary action.

I am indebted to Miss D. M. Brasher for stimulating discussions and helpful suggestions made while this communication was being written. I am also grateful to Dr. F. Wormwell for his encouragement and advice. This is published by permission of the Director of the Chemical Research Laboratory.

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Titration of Mixtures of Acids

The determination of the degree of polymerization of polyamides or polypeptides by end-group titration is, in effect, a determination of the amount of the weakly acidic carboxyl group (dissociation constant K_2) in presence of a large excess of the base of a stronger acid, the amide or peptide group (dissociation constant K_1).

A similar, but simpler, problem arises in the titration of weak dibasic acids when it is usually assumed[1] that if K_1/K_2 is greater than 4 the titration curve can be distinguished from that of a monobasic acid. Calculated titration curves for dibasic acids having different values of K_1/K_2 ranging from 4 to 100 show that it must be far larger than 4 before the end-point of the weaker acid can be visually detected.

The following argument leads to a more general relationship which can be applied to all mixtures of two acids, and which agrees with the conclusion drawn from the calculated curves.

If a_1 is the concentration of the stronger acid, and a_2 that of the weaker acid, then if the total concentration of acid in the undissociated form is A (when the hydrogen ion activity is H), the slope of the titration curve is given by:

$$\frac{dA}{d(pH)} = -2{\cdot}303\left[\frac{K_1a_1H}{(K_1+H)^2} + \frac{K_2a_2H}{(K_2+H)^2}\right] \quad (1)$$

Consider the central point of inflexion of this curve. There, $K_1 > H > K_2$, and at this point, to a sufficiently close approximation,

$$\frac{dA}{d(pH)} = -2{\cdot}303\left(\frac{Ha_1}{K_1} + \frac{K_2a_2}{H}\right) \quad (2)$$

Differentiating (2) and equating to zero (for a point of inflexion) gives:

$$\frac{d^2A}{d(pH)^2} = (2{\cdot}303)^2\left(\frac{a_1}{K_1} - \frac{K_2a_2}{H^2}\right) = 0 \quad (3)$$

Hence, here

$$H^2 = K_1K_2\left(\frac{a_2}{a_1}\right) \quad (4)$$

and

$$\frac{dA}{d(pH)} = -4{\cdot}606\sqrt{\frac{K_1a_1a_2}{K_2}} \quad (5)$$

Unless the slope of the curve at this point differs from that at the mid-point of the weaker acid, there will be no perceptible point of inflexion. At this mid-point, $H = K_2$ and (1) assumes the form:

$$\frac{dA}{d(pH)} = -2{\cdot}303\left(\frac{K_2a_1}{K_1} + \frac{a_2}{4}\right) \quad (6)$$

Equations (5) and (6) thus give the condition for the detection of the end-point of complete titration of the weaker acid, namely:

$$\sqrt{\frac{K_1a_1a_2}{K_2}} > \frac{K_2a_1}{K_1} + \frac{a_2}{4} \quad (7)$$

or

$$K_1/K_2 > 59{\cdot}7\ (a_1/a_2) \quad (7a)$$

For a dibasic acid, $a_1 = a_2$; thus the ratio of the dissociation constants must be larger than 59·7, not 4, before each group can be distinguished in the titration curve. This is in close agreement with the empirical conclusion reached by studying the theoretical curves.

It also follows that for a polymer containing a_1 amide groups and a_2 carboxyl end-groups, the degree of polymerization (a_1/a_2) must not be too large or, for a given ratio of dissociation constants, the end-point corresponding to complete titration of the carboxyl groups will be undetectable. In polyglycine, for example, pK_2 appears to be about 3·0 (according to data for its titration with hydrochloric acid), whereas pK_1 seems to be about zero[2]. With this polymer, therefore, the highest degree of polymerization which can be determined by hydrochloric acid titration is 1,000/59·7 = 16. Meggy and Sims[2] were able to overcome this limitation by using colour acids which, in effect, increase the affinity of the groups responsible for colour take-up and thereby

effectively vary the *pK* of these groups. Similar conclusions can be drawn from published data for nylon[3], and it is obvious that the above result has wide applicability.

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Recrystallization and the Ductility of Chromium

Unusual features observed during work on the ductility of chromium were the difficulty of detecting the completion of recrystallization of cold-worked material and the sensitivity of the ductile/brittle transition temperature of recrystallized material to small amounts of deformation, either residual or imposed.

The transition temperature of cold-rolled chromium (0·002 wt.–per cent nitrogen, 0·01 wt.–per cent oxygen) increased from − 60° C. to 130° C. or 380° C. on annealing at 1,050° C. or 1,100° C. respectively. Both treatments appeared to give completely recrystallized material of similar grain-size as judged by microscopic and normal X-ray back-reflexion examination. A distinction between the two materials could, however, be made using the more sensitive micro-focus X-ray technique, which revealed that the specimens annealed at 1,050° C. were not free from strain while those annealed at 1,100° C. were. This apparent marked dependence of transition temperature on residual cold work could explain the comparatively low and variable increases in transition temperature (70–200° C.) recorded by other workers on recrystallizing cold-worked chromium[1,2], although nitrogen content might also be important in this regard.

The following experiments indicate the sensitivity of the ductile/brittle transition temperature of recrystallized chromium to small amounts of deformation and emphasize the value of the micro-focus technique. As noted previously, wrought chromium strip recrystallized by annealing at 1,100° C. for two hours had a transition temperature of 380° C. However, similar strip sheath-rolled in mild steel and given an identical thermal treatment in the sheath had a consistently low transition temperature around − 55° C. Three possible explanations of this effect were suggested: (1) brittleness of the vacuum-treated specimens was due to impurity pick-up which did not occur in sheathed specimens; (2) heating-rate as well as cooling-rate could have been a factor as has been found with molybdenum[3]; (3) the low transition temperature of sheathed specimens was a result of deformation of the specimen by the sheath during cooling due to differential thermal contraction.

Neither of the first two possibilities was particularly attractive, and each was readily disproved by experiment. To test the third possibility, a type of 'sandwich' specimen was used comprising a strip of chromium between two much thicker strips of mild steel, the whole assembly being sealed under argon in a close-fitting mild-steel capsule. In one set of specimens the chromium and mild-steel 'sandwich' components were welded together at their ends before being sealed into the capsule, while in the other set the ends were left free. After heating the capsules at 1,100° C. in air for 2 hr. and slow cooling, it was found that the chromium strips which had been forced to expand and contract with the mild steel during heating and cooling were ductile at 0° C. whereas the remainder were brittle. No deformation could be detected in any of these specimens by the normal X-ray back-reflexion method. However, the micro-focus technique showed evidence of plastic deformation (~ 0·1 per cent strain) in strips which had been welded to their mild-steel supports while none could be detected in unwelded specimens.

Brandes and co-workers[4] have reported that compacted flake chromium, extruded at 1,200° C. in a sheath, can show ductility in bending at − 30° C. even though the nitrogen content was as high as 0·091 wt.–per cent. X-ray diffraction photographs of the material showed full recrystallization. The above work would indicate that Brandes's result possibly arose because (*a*) the material was not in fact fully recrystallized or (*b*) deformation occurred during cooling after extrusion due to a sheath effect and that the X-ray technique used was not sufficiently sensitive to detect residual cold work arising from either of these possibilities. Another possible explanation is that it is understood that the practice in Brandes's work was to determine the lowest temperature at which deformation occurred by bending a single specimen at an elevated temperature initially and then at successively lower temperatures until finally it broke in a brittle manner. Other work[2,5] indicates that this is not a valid procedure if an accurate measure of transition temperature is required.

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Strain-Age Hardening and Brittleness in Chromium

Current theories of the cause of brittleness in 'pure' chromium ascribe the phenomenon to Cottrell locking[1], invoking the Mott–Stroh[2,3] theory of crack formation as the operative mechanism of brittle fracture, and nitrogen as the associated interstitial solute atom. There are several features of the tensile behaviour of annealed chromium (containing approximately 0·002 per cent nitrogen and 0·015 per cent oxygen), however, which this picture does not wholly explain, namely: (1) the very high temperature up to which embrittlement extends (about 350° C.)

compared with other body-centred cubic metals of similar structure such as α-iron, molybdenum and tungsten; (2) the abrupt nature of the transition from a highly ductile condition to a completely brittle one, behaviour which again differs markedly from other body-centred cubic metals; (3) the fact that embrittlement occurs (at this nitrogen level) at the bottom of a trough in the maximum stress/temperature and yield stress/temperature curves just below 350° C.[4], and not on the steeply rising part of the yield stress/temperature curve, which occurs only below 200° C., and which has been ascribed directly to Cottrell locking.

Evidence is accumulating at these Laboratories which suggests that embrittlement of chromium may be caused primarily by the strain-induced precipitation, from highly super-saturated solid solution, of a chromium nitride and possibly also of a chromium oxide. The process appears to be highly sensitive to applied plastic strains, and to some extent resembles the strain–age hardening process which occurs in α-iron containing nitrogen[5].

Extrapolation of current data[6] suggests a solid solubility of about 10^{-5} per cent nitrogen in chromium at 400° C., falling to 10^{-10} per cent at 200° C.; it is to be expected, therefore, that almost the whole of the nitrogen ($1{\cdot}5 \times 10^{-3}$ wt. per cent) in chromium of the present purity would be available for precipitation between 400° C. and 200° C., a range of temperature which coincides with the ductile-brittle transition in this material in the annealed condition.

Evidence for the strain–age hardening process in pure chromium may be summarized as follows: (1) Repeated straining in tension to just beyond the yield point at 400° C. results in a distinctly stepped curve typical of an age-hardening alloy[7] as shown in Fig. 1, where the flow stresses of successive loadings rise appreciably above the preceding maximum applied stress. This effect occurs in varying degrees between 200° C. and 500° C., as shown in Fig. 2. The increment in flow stress was in general more sensitive to temperature and strain than to time of ageing between successive strains, that is, precipitation occurred mainly during or immediately after straining. Accordingly, the results in Fig. 2 are plotted as increment in flow stress against number of strainings.

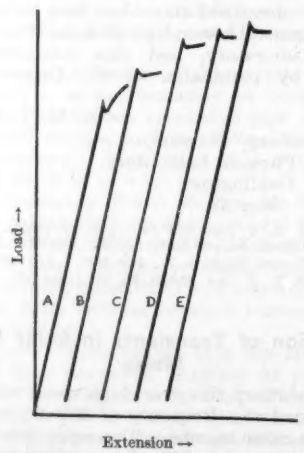

Fig. 1. Interrupted-loading tensile curves on high purity chromium at 400° C. (*A*) Strain, 1·1 per cent, 400° C.; (*B*) age, 1 min.; (*C*) age, 1,000 min.; (*D*) age, 1 min.; (*E*) age, 2 min.

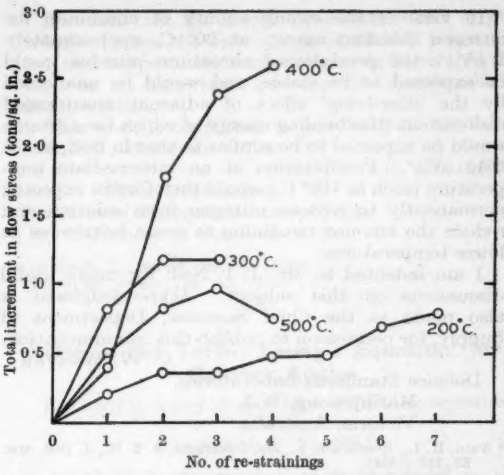

Fig. 2. Effect of temperature on the strain-age hardening of high purity chromium (0·0015 per cent nitrogen, 0·02 per cent oxygen).

(2) Pronounced age-hardening has been observed between 200° C. and 400° C. on chromium samples quenched from 1,250° C. Samples containing from 0·1 per cent down to 0·005 per cent nitrogen contained traces of precipitated particles in the microstructure which were revealed under phase contrast. Age-hardening also occurred at a level of 0·0015 per cent nitrogen, but no precipitated particles were visible.

(3) The ductile-brittle transition in tension of annealed chromium was lowered from 350° C. to 150° C. by lowering the nitrogen content from 0·0015 per cent to 0·0005 per cent. In this latter case brittle fracture occurred on the rising part of the yield stress/temperature curve in a manner similar to other body-centred cubic metals, but the brittle fracture stress was still comparatively low. This lowering of the transition temperature may be ascribed to the reduction of the mass-embrittling effects of precipitation consequent on a lower order of solute content; the abrupt incidence of completely brittle fracture below 150° C. indicates, however, that the precipitation mechanism continues to operate even at this low level of nitrogen.

(4) Deformation in the ductile range (that is, at 350° C. or above) results in a substantial lowering of the ductile-brittle transition, for example, a prestrain as small as 3 per cent at 400° C. resulted in high ductility at room temperature, with an elongation of 63 per cent and a reduction of area of 76 per cent. A notable feature of these tests was the lowering of the yield stress from 20–25 tons per square inch in the unstrained (brittle) condition to 15 tons per square inch in the prestrained (ductile) condition. The explanation now offered for this behaviour is that prestraining accelerates precipitation of nitride and that under appropriate conditions (for example, about 3 per cent strain at 400° C.) over-ageing advances far enough to depress the ductile-brittle transition to below room temperature. Further evidence for this view will be advanced in a paper shortly to be published.

In view of the strong affinity of chromium for nitrogen (binding energy at 20° C. approximately 1 eV.)[8], the precipitated chromium nitrides would be expected to be stable, and would be unaffected by the 'dissolving' effect of adjacent unsaturated dislocations (the binding energy of which for nitrogen would be expected to be similar to that in iron, about 0·45 eV.)[9]. Precipitation at an intermediate temperature (such as 400° C.) would therefore be expected permanently to remove nitrogen from solution and reduce the amount remaining to cause brittleness at lower temperatures.

I am indebted to Mr. J. I. Nish for many useful discussions on this subject. Acknowledgment is also made to the Chief Scientist, Department of Supply, for permission to publish this communication.

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Effect of Stress on Hole Formation during the Diffusion of Zinc from Brass *in vacuo*

It has been suggested by Greenwood[1] that intergranular fracture during deformation at elevated temperatures, which occurs by the linking together of isolated holes at grain boundaries, is the result of precipitation of excess vacancies produced by the deformation. Some doubts have been cast on this view. For example, in diffusion couples, holes may be formed by the precipitation of excess vacancies produced by the unequal rates of diffusion of the components, but these holes have little preference for grain boundaries. An exception to this can occur, however, during the diffusion of zinc from brass *in vacuo*, and Balluffi and Seigle[2] have suggested, without proof, that in this case the preferential formation of holes at grain boundaries is associated with the presence of stress.

In the course of an investigation of the effect of applied stresses on brass foils, 0·001 in. thick, during the removal of zinc by diffusion *in vacuo* it has been found that the presence of stress markedly affects the distribution of holes. Fig. 1,*a* shows randomly distributed holes in a brass foil containing 0·2 per cent antimony which was tested free of stress *in vacuo* for 1 hr. at 800° C. to remove nearly all the zinc. I have shown previously[3] that the presence of 0·2 per cent antimony enhances the formation of holes during the removal of zinc. The same material fractured after 5 min. under a nominal stress of 170 gm./mm.^{2}, and Fig. 1,*b* shows that at this time the holes had formed preferentially at grain boundaries. To show that these cracks at grain boundaries were not due to the applied stress in the absence of an excess of vacancies produced by diffusion, a specimen was

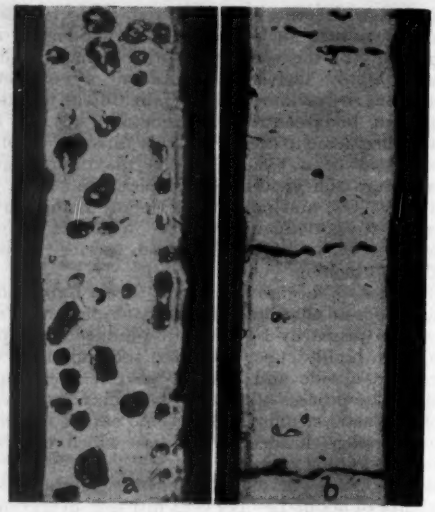

Fig. 1. Brass containing 0·2 per cent antimony. (*a*) Tested free of stress. Random distribution of holes. (*b*) Broke after 5 min. under stress. Preferential formation of holes at grain boundaries. × 750

tested under the same conditions except that, to prevent removal of the zinc, the specimen was surrounded by an atmosphere of oxygen-free nitrogen and by a tube of the same composition as the specimen open only at the end through which the load was applied by a fine wire. There was no change of length of this specimen, and a micro-section showed no holes either at grain boundaries or within the grains. A test on a copper–0·2 per cent antimony alloy containing no zinc similarly produced no holes, although there was a slight extension of 1·3 per cent. Thus the presence of stress alone before or after the removal of zinc did not produce intergranular cracks. It can therefore be concluded that under these conditions of test the simultaneous action of stress and of excess of vacancies is necessary to produce holes and cracks forming preferentially at grain boundaries.

The work described above has been carried out as part of the general research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory.

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Duration of Transients in Solar Radio Noise

Since February this year, high-speed records have been obtained at a frequency of 200 Mc./sec. during solar radio noise storms. The equipment used for the registrations consists of a receiver with bandwidth of 0·3 Mc./sec. and time constant 0·01 sec. and a Brush recorder. Records were secured at

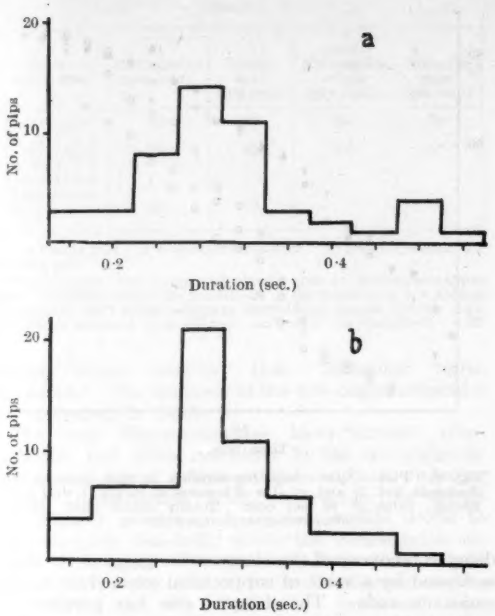

Fig. 1. Distribution of pips of different duration. (*a*) May 9 and (*b*) August 28, 1957

various paper speeds, with a speed of 25 mm./sec. as that mostly used, since this speed seems to give the best compromise between the competing factors resolving power, amount of information and paper consumption.

Records show that bursts, as recorded on a usual low-speed recorder, can be resolved into several pips. Measurements of the duration of these pips, taken between half-power points, have been carried out on records from May 9 and August 28 this year. The histograms of Fig. 1 show the distribution of pips of different duration. In the first case, 50 pips were analysed, in the second 64 pips. Both histograms reveal a rather sharp peak at 0·28 sec. The mean duration of pips on the two days was found to be: May 9, $0{\cdot}30 \pm 0{\cdot}02$ sec.; and August 28, $0{\cdot}28 \pm 0{\cdot}01$ sec.

A remarkable feature of the records taken is that pips have a strong tendency to occur in groups. The interval between successive pips was measured for several groups, and the following mean values were obtained: May 9, $0{\cdot}51 \pm 0{\cdot}02$ sec.; and August 28, $0{\cdot}54 \pm 0{\cdot}03$ sec.

At a frequency of 400 Mc./sec., de Groot[1] reports a sharp maximum for a duration of $0{\cdot}18 \pm 0{\cdot}03$ sec. in his material of 500 bursts covering several noise storm periods. On the particular date August 29, 1956, the mean duration of pips was $0{\cdot}13 \pm 0{\cdot}03$ sec., and the mean interval between successive pips was $0{\cdot}25 \pm 0{\cdot}03$ sec.

Comparing these results with my observations, it is seen that the mean duration of pips is halved when the wave-length is doubled. This supports the results reported by Reber[2] that there is a linear relationship between wave-length in metres and duration of pips in seconds. The constant of proportionality is close to 0·2 and not unity as mentioned by Reber.

The fact that the frequency of occurrence of pips is halved when the wave-length is doubled is interesting, and supports the suggestion by de Groot that this may be an important quantity for the theoretical interpretation.

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Use of the Term 'Young's Equation' for Contact Angles

Recently, many writers have called the equation:

$$\gamma_S = \gamma_{SL} + \gamma_L \cos\theta \qquad (1)$$

in which θ is the contact angle measured in the liquid, γ_L, γ_S and γ_{SL} the surface tensions of liquid, solid and solid–liquid surfaces, 'Young's equation'. I suggest that the relation between work of adhesion W_{SL}, contact angle, and surface tension of the liquid:

$$W_{SL} = \gamma_L(1 + \cos\theta) \qquad (2)$$

would more appropriately be called 'Young's equation'. In his "Essay on the Cohesion of Fluids", Thomas Young[1] began his section VII, on "Cohesive Attraction of Solids and Fluids", thus:

"When the attraction of the particles of a fluid for a solid is less than their attraction for each other [that is, when $W_{SL} < 2\gamma_L$] there will be an equilibrium of the surface forces, if the surface of the fluid make with that of the solid a certain angle, the versed sine of which is to the diameter, as the mutual attraction of the fluid and solid particles [W_{SL}] is to the attraction of the particles of the fluid among each other [$2\gamma_L$]." It becomes clear later, when Young discusses the forces parallel to the surface, that his angle (φ) is the supplement of the usual contact angle θ in the liquid. The ratio of versed sine to diameter is $(1 - \cos\varphi)/2$ or $(1 + \cos\theta)/2$. Young's extraordinary insight in seeing, apparently without formal derivation, that this ratio equals $W_{SL}/2\gamma_L$, thus stating equation 2 in archaic but quite definite trigonometrical terms, could properly be commemorated by giving his name to this equation. Equation 1, obtained by merely resolving the forces parallel to the solid surface, is not only almost self-evident but also is far less useful than (2), since the two solid surface tensions γ_S and γ_{SL} cannot be measured with any accuracy. Young not only stated equation 2 but he also indicated its limitation, for it becomes meaningless when W_{SL} is greater than $2\gamma_L$.

Perhaps the reason why recent writers have not called equation 2 by Young's name is that Harkins and Livingston[2], for no very obvious reason, said that "it is extremely unfortunate that this equation came into notice at all", and deprecated its attribution to Young because he stated it in words, the significance of which they found "not clear". I hope the above quotation and comments now show that the relation (2) was clearly understood and stated by Young. The only "unfortunate" incident may be that Young's name has recently been attached to the less important and more obvious relation (1), instead of

to the very illuminating (2), which is much the more important discovery, because it relates the contact angle to the relative adhesion of liquid to solid and of liquid to liquid.

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Relation of Size of Electroretinogram to Rhodopsin Concentration in Normal Human Beings and one Totally Colour Blind

The surprising fact that during regeneration of rhodopsin in the dark after sufficient light adaptation the electroretinogram does not begin to increase in size until some 50 per cent rhodopsin has been regenerated was originally demonstrated in cats and frogs[1]. Fig. 1 (open circles) shows that also in light-adapted man (three cases) there is an initial phase of very slow recovery of the *b*-wave of the electroretinogram in the dark, followed by a faster rise. On the suspicion that the initial delayed recovery might be due to a general suppression of rod-action on the part of the cones the experiment was repeated with a cone-blind woman. Her electroretinogram (Fig. 1, filled circles), indeed, showed no initial period of delay but began to rise immediately, as does regeneration of rhodopsin. It was 3 min. before the controls showed any response at all.

Fig. 2 is a comparison of the electroretinographic data with rhodopsin densities during regeneration in the dark, as directly determined[2] by Rushton's ophthalmoscopic method. The rhodopsin densities (crosses) are in good agreement with the electroretinographic values of the totally cone-blind, replotted in the figure on a percentage basis (filled circles), while the normal eyes (open circles, also replotted from Fig. 1) show the delay. At this stage no stress is laid on the precise agreement between the two sets of data, only on the absence of delay in the electroretinogram of the totally colour blind. The results, therefore, bear out the hypothesis that the delayed recovery of the electroretinogram in the dark is caused by a state of suppression exerted by active cones on rods. The delayed rise has parallels in perception.

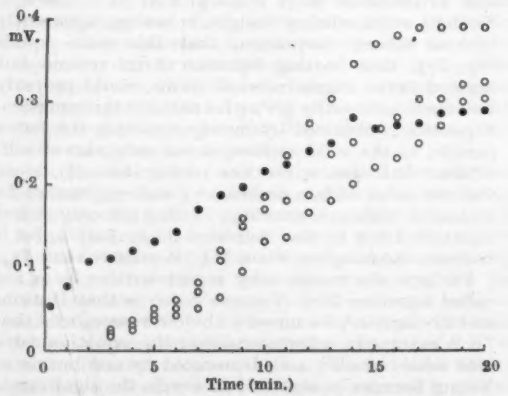

Fig. 1. Increase in mV. in the dark of the *b*-wave of the electroretinogram of one totally colour blind (filled circles) and three controls (open circles), one of which has a particularly large *b*-wave in the dark though none immediately after light adaptation. Light adaptation for 10 min. to 1,000 Lux white light. For the first 3 min. the controls did not have any measurable electroretinogram whereas the totally colour blind immediately responded with a small *b*-wave

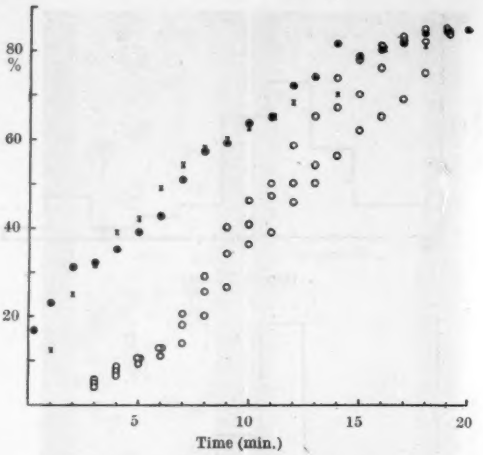

Fig. 2. Plot of percentage regeneration in man (crosses) of rhodopsin (ref. 2) and of size of *b*-waves as in Fig. 1 with the 20-min. value at 85 per cent. Totally colour blind (filled circles) and controls (open circles)

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The Hyaluronidase of the Leech: an Endoglucuronidase

Two types of hyaluronidases have been described: one, found in testicular extracts and in snake venom, randomly cleaves the hexosaminidic bonds and yields a consecutive series from disaccharide through higher homologues of disaccharide units[1]; the other, found in micro-organisms, yields a Δ4–5 (glucuronido) unsaturated disaccharide[2]. In this communication, a third type of hyaluronidase is described, found thus far only in extracts of the leech (*Hirudo medicinalis*), which hydrolyses the endoglucuronidic linkages of hyaluronic acid.

The presence in the leech of a potent hyaluronidase had been noted previously, including its effect on the physical properties of hyaluronic acid, the production of reducing sugars and its action as a spreading factor[3]. Paper chromatograms of the products of the 24-hr. digestion of sodium hyaluronate by the leech enzyme and by testicular hyaluronidase[1] showed a similar distribution of oligosaccharides. The leech digest products had, however, slower mobilities and also differed markedly from those obtained by microbial hyaluronidase. The major fraction of 'leech' oligosaccharides (on exhaustive digestion) was isolated by ion exchange chromatography. On paper, it produced a single spot with a

Table 1

Tetrasaccharides	Hexosamine (per cent)	Uronic acid (per cent)	Acetylglucosamine colour (per cent)	Reducing sugar (per cent)
Testis enzyme (*U–A–U–A·*)	43	49	68	53
Leech enzyme (*A–U–A–U·*)	38	45	18*	37
Reduced leech tetrasaccharide	38	26		1

U = uronic acid; *A* = acetylhexosamine. *A·* and *U·* denote the reducing end.

* Theoretically, this compound should give no acetylglucosamine colour. However, under the conditions of the reaction (0·5 *N* sodium carbonate at 100°) some end-group degradation occurs. Similar *AGA* values were obtained with *U–A–U·* and *A–U·* as described.

slightly slower mobility than 'testicular' tetrasaccharide[1]. The analyses of the two oligosaccharides are compared in Table 1.

The two oligosaccharides have similar compositions, but differ markedly in the acetylglucosamine end-group colour value[1] and in reducing value. On reduction with borohydride, the uronic acid content of the leech oligosaccharide drops to approximately one-half, while the hexosamine remains unchanged. We conclude from the analysis and general properties that the 'leech' oligosaccharide, in contrast to the 'testicular' tetrasaccharide, is a tetrasaccharide having a uronic acid at the reducing end-group. This finding indicates that the leech enzyme hydrolyses endo-glucuronidic bonds, while testicular and microbial hyaluronidases split endohexosaminidic bonds. In accordance with this hypothesis, hexasaccharide (from testicular digests[1] (*U–A–U–A–U–A·*) was hydrolysed by the leech enzyme to two trisaccharides of the composition *U–A–U·* and *A–U–A·*. No reducing hexosamine end-group was ever found in 'leech' digests of hyaluronic acid. No transglycosylative action[4], in contrast to that of testicular and snake venom hyaluronidase, was observed on 'leech' oligosaccharides or on 'testicular' oligosaccharides with leech enzyme. Furthermore, leech extracts do not contain an exoglucuronidase[5].

Confirmation of the structure of the leech oligosaccharides has been obtained by the action of weak alkali on various oligosaccharide fractions. On treatment of *N*-acetylhyalobiuronic acid[1] with saturated lime water at room temperature for 4 hr., glucuronic acid and anhydroacetylglucosamine are obtained. This reaction is analogous to the action of alkali on various disaccharides, including galactosido-*N*-acetylglucosamine[6]. D-Glucuronic acid was stable under our conditions. When 'testicular' hyaluronate tetrasaccharide (*U–A–U–A·*) was treated with lime water, anhydro-*N*-acetylglucosamine and the alkali-stable trisaccharide *U–A–U·* were obtained. The composition of the trisaccharide was confirmed by analysis and its properties. From this trisaccharide, the disaccharide *A–U·* (an isomer of *N*-acetylhyalobiuronic acid) was prepared by hydrolysis of the non-reducing uronic acid with β-glucuronidase[5]. From leech tetrasaccharide (*A–U–A–U·*), a trisaccharide (*U–A–U·*) and free *N*-acetylglucosamine were obtained after hydrolysis of the non-reducing glucosamine end-group with liver β-glucosaminidase, which had been shown previously to split *N*-acetylglucosamine only from the non-reducing end of odd-numbered oligosaccharides[6]. The trisaccharide *U–A–U·* was identical in R_F value, in composition, reducing and acetylglucosamine end-group value (see footnote of Table 1) with that obtained by treatment with lime water of *U–A–U–A·* (the 'normal' tetrasaccharide of hyaluronic acid). These results confirm the structure of the leech tetrasaccharide as *A–U–A–U·*.

The compounds obtained by leech hyaluronidase and by the combination of alkaline and enzymatic degradation represent a new series of oligosaccharides derived from hyaluronic acid. Therefore, it is now possible to prepare oligosaccharides with any combination of reducing and non-reducing end-groups. These may be useful in biosynthetic studies.

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A Highly Specific Growth-inhibitory Factor produced by Certain *Acetobacter* Species

Recent studies[1] with a cellulose-producing culture of *Acetobacter acetigenum* NCIB 8132 revealed that this culture contained mutant organisms which were unable to produce extracellular cellulose (celluloseless mutants). Their presence in the wild-type culture was indicated by a mass-plating technique in which a large inoculum from a cellulose-producing culture was spread on the surface of glucose (3 per cent, w./v.), 'Difco' yeast-extract (0·5 per cent, w./v.) (*GYE*) medium (*p*H 7·0) containing agar (2 per cent, w./v.); mutant organisms showed a different colony type and a faster growth-rate than wild-type organisms. In *GYE* liquid medium parent organisms produced a cellulose pellicle, the medium under the pellicle remaining virtually clear. In contrast, mutant organisms grew diffusely in liquid medium and produced a moderate degree of turbidity. Despite the fact that mutant organisms could be detected in wild-type cultures by the mass-plating procedure, all our attempts to isolate mutants from cellulose-producing cultures by the indirect-selection method of Lederberg and Lederberg[2] have been unsuccessful. The present work was undertaken in an attempt to clarify this contradictory behaviour.

In preliminary experiments (*GYE* medium), made with artificial mixtures of parent and mutant organisms, the parent overgrew the mutant organisms regardless of the age of either culture. Also, mutant organisms failed to produce turbidity when inoculated into parent cultures. Mutant organisms grew well

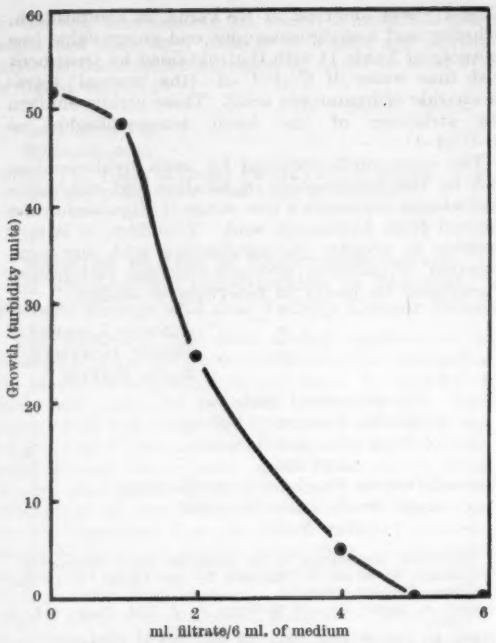

Fig. 1. Growth of mutant organisms in dilutions of filtrate obtained from a culture (6 days) of *Acetobacter acetigenum* NCIB 8132. (Where necessary, the filtrate was made up to a final volume of 6 ml. with *GYE* medium; growth was recorded at 3 days)

when inoculated into Seitz filtrates (*p*H 6·0) of 24 hr. wild-type cultures but not in filtrate of 48 hr., or older, parent cultures even when these were supplemented with glucose and yeast extract. Growth of mutant organisms in various dilutions of wild-type filtrate (6 days) is shown in Fig. 1. The activity of the growth-inhibitory factor was apparently unaffected by heat sterilization (15 lb./sq. in. for 15 min.).

When each of thirteen species of bacteria representing ten genera were tested for their ability to grow in filtrate (*p*H 6·0) of organism NCIB 8132, only the growth of *Proteus vulgaris* was inhibited; a control culture of this organism in *GYE* medium gave good growth. This selective behaviour of the inhibitor was confirmed in several subsequent trials in some of which both glucose and yeast extract were added to the filtrate.

Cellulose-less mutants obtained from cellulose-producing cultures of *Acetobacter acetigenum* NCIB 8132 and NCIB 5346, *A. xylinum* NCIB 8034, *A. xylinum* var. *africanum* NCIB 7029 and *Bacterium xylinoides* NCIB 4940 were examined for their ability to grow in the filtrate of their own parent culture and in the filtrate of each other parent culture. The filtrates were obtained from wild-type cultures at six days, were tested at *p*H 6·0, and after inoculation were incubated at 30° for four days. None of the mutant organisms grew in any filtrate except in that of culture NCIB 8034, which supported the growth of all mutant isolates. Each of the wild-type cultures grew well when inoculated into each of the parent filtrates.

It would appear that the production of a growth-inhibitory factor by the cellulose-producing organisms (except culture NCIB 8034) provides a selective environment for their propagation in *GYE* liquid medium. This also offers an explanation for our failure to obtain mutants from culture NCIB 8132 by the method of Lederberg and Lederberg[2]; the colonies (presumably containing both parent and mutant cells), picked from the 'master' plate to *GYE* liquid medium for enrichment of mutants, failed to enrich the mutants because their growth was inhibited. It is further suggested that, when the parent culture is mass-plated, the inhibitory factor is reduced in concentration by diffusion into the agar medium, thus allowing the mutant organism to grow. The growth-inhibitory factor is being studied further.

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Ultrastructure of Erythrocytes in Severe Scurvy

A survey of the literature has revealed that anæmia complicates 70 per cent of all clinical cases of severe scurvy[1]. The increased urobilinogenæmia of scurvy is evidence of an accelerated disintegration of erythrocytes[2]. These factors, combined with the recent demonstration of a hæmolytic process in human scorbutic patients[3], prompted us to study the effects of vitamin C deficiency on the ultrastructure of the erythrocytes of animals suffering from scurvy.

Two guinea pigs were made scorbutic by being fed an ascorbic acid-free diet for thirty days, killed and erythrocyte samples obtained from the coronary and femoral arteries and pulmonary capillaries. A

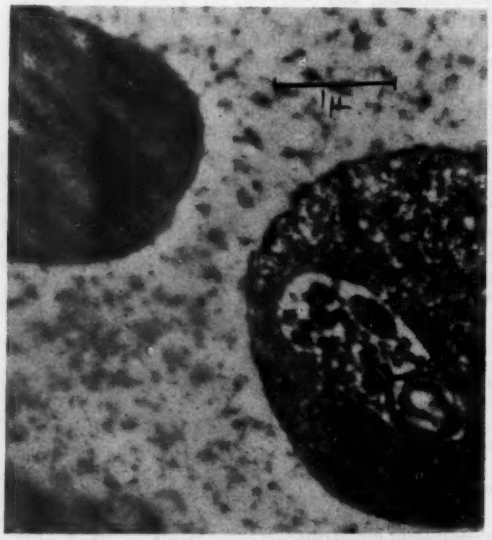

Fig. 1. Two red-blood cells in a capillary—a normal one, left, and a diseased one, right. The latter is slightly granulated. The vacuole contains debris of spherical and filamentous shape. × c. 18,000

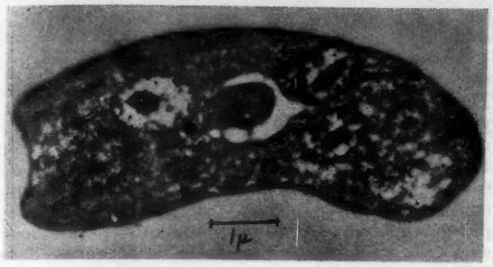

Fig. 2. Diseased erythrocyte as in Fig. 1. Vacuoles with membranes contain particles of different sizes. A chain-like structure exists in one of them. × *c.* 10,000

part of the cells appeared as if they had holes punched in them. Electron microscope pictures of ultra-thin sections revealed the presence of vacuoles with well-defined borders (membranes) enclosing either whole portions of the red-blood cell or cellular debris in the form of very small circular or ovoid bodies (500–2000 A. in diameter) or filamentous material (Figs. 1 and 2). Parts of these vacuoles do not contain any visible material; the latter is apparently digested and dissolved. The vacuoles increase in size, probably as a result of the hypertonicity of their contents. They finally empty into the surrounding blood stream, leaving behind cellular fragments which may still contain one or more vacuoles and their contents (Fig. 3).

Only a small number of the erythrocytes of two guinea pigs fed the scorbutogenic diet for ten days and two others fed the same diet for twenty days were vacuolated. Such cells were never observed in the blood of the seven control guinea pigs fed normal diets.

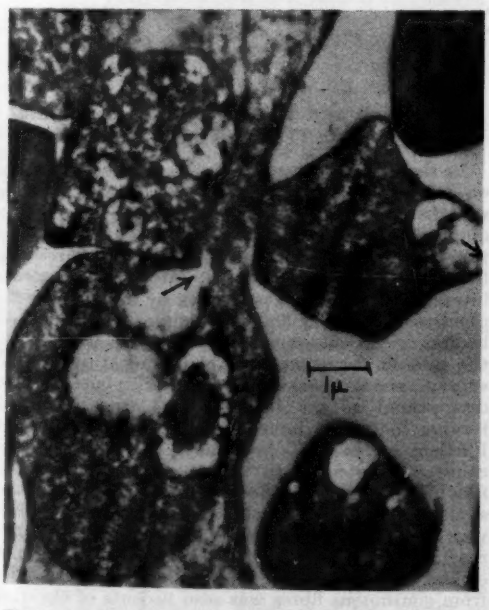

Fig. 3. A group of diseased erythrocytes from the same guinea pig. Some of the vacuoles are very close to the borders of the cell. Arrows point to two places where the vacuoles have burst. × *c.* 9,000

A more detailed report of these observations will appear in an early issue of *Experimental Medicine and Surgery*.

This investigation was supported by a research grant of the National Drug Co., of Philadelphia, Pa.

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Sodium, Potassium and Calcium Ions in the Hæmolymph of *Oncopeltus fasciatus* (Dallas)

THE inorganic constituents in the hæmolymph of insects have been investigated in many orders, according to the report of Florkin[1]. There is a dearth of information in the order Hemiptera. Mature adults of this species were used in this investigation.

Eggs were received from R. L. Beard, of the Connecticut Agriculture Experiment Station at New Haven, Connecticut. They were incubated at normal room temperature in deep glass dishes. Their food consisted of dried milk-weed seed and double glass-distilled water. By amputating a leg and antenna the blood was drawn up by capillarity into a micro-pipette. This pipette was graduated to a thousandth of a millilitre. After each bleeding the contents in the pipette were emptied into a 'Vycor' crucible, along with some double glass-distilled water, used to rinse the pipette. This mixture was ashed in a muffle oven at a temperature of 600° C. By pooling the blood of many specimens, samples of 0·1 and 0·5 ml. were tested. The ashed sample was dissolved in 5 ml. of 0·1 *N* hydrochloric acid and this solution was transferred to a small beaker of the Beckman flame photometer. Transmission readings of the sodium, potassium and calcium content were made, after having first adjusted the photometer with standard solution containing known amounts of each ion[2].

These observations on sodium and potassium are the only ones reported for the hæmolymph of *O. fasciatus* (Dallas). The average sodium content was 80·4 mgm. per cent or 39·52 m.eq. per litre. Potassium had a value of 80·2 mgm. per cent or 20·51 m.eq. per litre. The average 11·06 m.eq. per litre for calcium was observed in this experiment. Clark and Craig[3] reported calcium in this species as 13·9 m.eq. per litre. This value for sodium agrees with that obtained for the dipteran larva of *Dictenidia bimaculata* (L.). The potassium value agrees with that obtained in the larva of the lepidopteran, *Celerio* (*Deilephila*) *euphoribae* (L.), and the pupa of the coleopteran, *Hydrophilus piceus* (L.). Those insects the calcium content of which approximated that found in *O. fasciatus* (Dallas) were the pupa of the silkworm *Bombyx mori* and the adult of *Hydrophilus piceus* (L.)[1].

This project was suggested and supervised by Dr. D. Ludwig.

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Quantity of Radioactive Lecithin and Radioactive Cephalin with Lipositol required to produce Sphering of Mammalian Red Cells

The quantity of distearyl lecithin which has to be added to washed human red cells to produce the disk–sphere transformation has already been described[1]; 10^9 disks require 5–10γ, but how much of the material is adsorbed on the red cell surface is unknown.

Recently we have been able to label lecithin and cephalin plus lipositol with iodine-131, following a method essentially similar to that of Hoffman[2]. The lecithin and cephalin plus lipositol was provided us by the American Lecithin Co. as 'Alcolec Granules', which consist of about one-third lecithin, one-third cephalin, and one-third lipositol. This mixed material was dissolved in ether and brought into contact by shaking with $Na^{131}I$ to which a small drop of nitric acid had been added. After 24 hr., the ether layer was washed four times with potassium iodide and then four times with $Na_2S_2O_3$; it contains all the phospholipids. 20 vols. of acetone was added; a precipitate appears, which is dried in air. On adding ethyl alcohol to the dried material, some of it dissolves (lecithin), while the remainder dissolves on adding diethyl ether (cephalin plus lipositol). Sols of both lecithin and of cephalin plus lipositol were made by adding 1 ml. of the alcohol or ether solution to 9 ml. of saline at 60°, and were cooled slowly to room temperature and filtered.

To 0·5 ml. of a suspension of washed human red cells with a volume concentration of 0·3, that is, each 0·5 ml. containing $1·9 \times 10^9$ red cells, 0·5 ml. of the lecithin sol undiluted, diluted 1 in 2, 1 in 4, etc., was added. Similarly, to 0·5 ml. of a similar red cell suspension, 0·5 ml. of the cephalin plus lipositol sol undiluted, diluted 1 in 2, 1 in 4, etc., was added. Control systems contained 0·5 ml. of lecithin sol or of cephalin plus lipositol sol, undiluted or diluted 1 in 2, etc., added to 0·35 ml. of saline. After 15–30 minutes, each system containing red cells was examined by phase optics and between plastic slide and coverslip to see if sphering had occurred. If it had, the radioactivity of 0·5 ml. of the supernatant fluid from the red cell system and 0·5 ml. of the appropriate control was measured in a well-type scintillation counter. After subtracting background, the ratio (count in supernatant of cell suspension)/(count in control) enables one to calculate the minimum fraction of radioactive lecithin or of radioactive cephalin plus lipositol which is attached to the surface of the red cells when they are sphered. To convert this quantity into mgm., about 1 ml. of each of the two sols were weighed before and after drying; the sodium chloride in each was subtracted and the remainder was taken as being lecithin or cephalin plus lipositol.

In the case of both sols, the quantity taken up at the surfaces of the sphered cells was $0·1 \pm 0·02$ mgm. The relative quantities of lecithin and of cephalin plus lipositol in the human red cell are somewhat uncertain, but taking the values given by Williams, Erickson, Avrin, Bernstein, and Macy[3], lecithin and cephalin are present in about equal amounts, lipositol constitutes a very small fraction, and the total phospholipids in 0·5 ml. of a human red cell suspension of volume concentration 0·3 varies from 0·54 mgm.[4] to 0·44 mgm.[1]. Since an uptake of $0·10 \pm 0·02$ mgm. of either lecithin or of cephalin plus lipositol is the minimum amount which produces sphering of red cells which contain between 0·54 mgm. and 0·44 mgm. of phospholipids, sphering appears to occur when one out of four or one out of five cell phospholipids had combined with the added sphering agent. This supposes, however, that all the cell phospholipids are equally accessible (as they might be if the phospholipids formed a monolayer at the cell surface); but since there is evidence that at least 50 per cent of the cell lipid is bound to protein as a lipoprotein complex[4], speculation in this direction can be very misleading.

This investigation was made under a grant, *H* 1598, from the U.S. Public Health Service. We have to thank Mr. J. Eichberg, president of the American Lecithin Co., for material and for very helpful advice.

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Adrenaline and Failure of Neuromuscular Transmission

In the course of a study of the effects of adrenaline on neuromuscular transmission, we have observed repeatedly during tetanic stimulation of the rat diaphragm *in vitro* and gracilis *in vivo* failure of transmission of a type which has apparently received little or no attention in the literature. We recorded intracellular end-plate potentials by means of micropipettes filled with 3 *M* potassium chloride, which had an electrical impedance of 10–30 MΩ. When the muscle nerve was stimulated repetitively with supramaximal shocks, the muscle spike potential disappeared as the rate of stimulation increased, leaving only a diminishing end-plate potential. Further increase of frequency, however, did not cause this potential to vanish gradually. Instead, failure of transmission occurred at a point which was evidently *proximal* to the end-plate. This failure was initially intermittent: certain impulses did not reach the end-plate and hence made no impression on the end-plate resting potential (sometimes activity from continuous fibres was seen because of electrical spread).

Impulses which did reach the end-plate gave larger end-plate potentials than before, presumably because

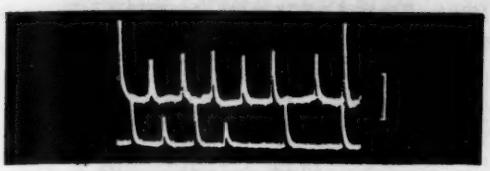

Fig. 1. Potentials recorded intracellularly from two separate end-plates during tetanic stimulation (64/sec.) of only one motor unit in a rat diaphragm, after dissecting a single motor fibre in the phrenic nerve. The end-plates show intermittent but asynchronous failure of transmission. The voltage calibration at right of figure indicates 5 mV. for upper trace and 15 mV. for lower trace

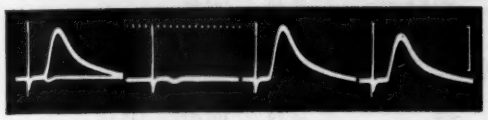

Fig. 2. Photographs of intracellular end-plate potentials from a fibre in a rat diaphragm illustrating the beneficial action of adrenaline on failing neuromuscular transmission. The photographs record about twenty superimposed oscilloscopic traces each; they should be read from left to right: (1) Intermittent failure of transmission during supramaximal stimulation at 20/sec. (2) Five seconds after the addition of 50 μgm. adrenaline hydrochloride to the bathing solution. At this time failure had become complete, but there was some activity in adjacent fibres. Partial recovery began 10 sec. later. Time scale: 1 msec. (3) Fifty-five seconds after the injection: there was complete recovery of transmission at 20/sec. (4) Five minutes after the injection. Stimulation at 50/sec. Vertical scale, 10 mV.

the end-plate was now being stimulated at a lower effective rate. The frequency at which failure began varied considerably with different fibres, with the condition of the muscle, and with the supply of oxygen. The partial block could usually be relieved by lowering the rate of stimulation. In some cases, however, this was not true, and complete, apparently irreversible block ensued. Recording of the activity in the nerve trunk showed that failure of conduction did not take place in the nerve trunk.

In preparations in which a single motor fibre was dissected in the phrenic nerve, the potentials at end-plates of two active muscle fibres did not fail synchronously (Fig. 1). This shows that the failure of transmission was occurring beyond the most distal point of branching of the motor axon, that is, close to or at the nerve ending. We found, both *in vitro* and *in vivo*, that adrenaline (hydrochloride or bitartrate) injected either into the muscle bath (50 μgm. in 30 ml.) or intra-arterially (1–2 μgm.) usually relieved such a partial block (Fig. 2).

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Role of Damaged Starch in the Evaluation of Wheat Quality

The introduction of test baking as a means of quality evaluation in the wheat-breeding programme of the Agricultural Research Institute, Wagga, has disclosed a characteristic which does not appear to have been reported in Australian wheats, namely, differential susceptibility of varieties to excessive starch damage during milling. This has been confirmed by microscopic examination with differential staining as used by Jones[1]. Trials by experienced technicians using different experimental mills showed that, with certain wheats, excessive starch damage could not be avoided. In the test-bake, this excessive proportion of damaged starch led to high water absorption, poor loaf volume and crumb texture on the basic test, and 'stickiness' in doughs containing diastatic malt.

The question arose as to why a high proportion of the wheat breeder's cross-breds and some commercial varieties—all of which had been regarded as having superior 'strength' but which did not always perform well under test-baking—should possess this characteristic.

The explanation appeared to lie in the choice of methods previously used for assessing quality. Early selection for quality was based in the first place on the wheat-meal fermentation-time test. With this test the higher water absorption caused by damaged starch leads to a 'tight' dough-ball and consequently a high figure which was interpreted as superior quality. (Incorporation of varying proportions of damaged starch in the dough-balls has confirmed this view.)

Subsequent testing at a more advanced stage in the breeding has been carried out on the farinograph. Trials with flour samples containing increasing proportions of damaged starch (artificially produced) showed that the farinograph revealed no effect due to the additions except an increase in water absorption—a characteristic ordinarily regarded as desirable.

Extensive trials with the Chopin alveograph have shown that a moderate amount of damaged starch manifests itself as enhanced strength and better balance. Only in cases of extreme 'toughness' due to high absorption by damaged starch would one regard the sample as having undesirable characteristics.

If such techniques are to be used in place of test-baking in assessing baking quality of wheats, then it appears imperative that they should be used in conjunction with supplementary tests to show whether the results are an indication of genuine strength, or just 'pseudo-strength' caused by some anomalous characteristic such as excessive starch damage.

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Silk Production in the Cheyletidae (Acarina: Arachnida)

While examining some grain infected with tyroglyphid mites, I found a specimen of *Cheletomorpha lepidoptorum* Shaw (=*venustissima* Berlese), which had just finished laying eggs. About six eggs were scattered on the ground, and the *Cheletomorpha* was moving backwards and forwards, covering them with a sparse network of silk. In this mite, the mouth is at the end of a gnathosoma, which is shaped like a cone and completely encircles the cheliceral stylets. The silk was coming from the mouth in the form of a very fine thread, which was stretched from side to side over the eggs, the pedipalpal claw being used for manipulating it at times. Unlike *Cheyletus eruditus*

Schrank, which remains crouched over its eggs until the larvæ emerge, the *Cheletomorpha* took no further interest in the welfare of its young, but wandered away to lay a few more eggs in another place.

Silk production is common in the Tetranychidae; but it has not previously been recorded in the Cheyletidae, and it is possible that, in *Cheletomorpha*, part of the salivary gland is modified for this purpose.

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Control of Flowering in Rice by Plant-Growth Substances

There is a difference of opinion regarding the presence or absence of florigenic properties of the plant-growth substances. The flowering behaviour of various crop plants as influenced by these substances has been studied by many workers in the field[1-5]. The present investigation aims at studying the effect of various plant-growth substances such as β-indolylacetic acid, α-naphthylacetic acid and 2,3,5-triiodobenzoic acid on the flowering of four different varieties[6] of rice.

Pure grains of the varieties *N*.136 (early), *T*.1145 (early-winter), *T*.141 (mid-winter) and *J*.192 (late-winter) were procured from the Central Rice Research Institute, Cuttack. After a preliminary selection for uniformity, the seeds were soaked in three different concentrations, 500, 250 and 100 p.p.m., of each of the three different plant-growth substances for 72 hr. The grains thus treated were washed thoroughly in water and then sown in seed-bed pots. At the age of 21 days, the seedlings were transplanted to 10-in. earthenware pots containing a mixture of soil and cow-dung manure in the proportion of 8 : 1. The plants were next subjected to weekly foliar spray with the corresponding hormone solution in which the seeds were soaked previously. The spraying was commenced with 28-day-old-seedlings and was continued until the panicles emerged in each plant. Care was taken to maintain uniform soil moisture throughout the experimental period by frequent applications of water.

The criterion of ear emergence was taken as the exsertion of the floral axis through the flag leaf sheath of the main shoot. Observations were taken each day at about 9 a.m. The number of days taken from sowing to ear emergence is presented in Table 1. The results indicate a wide difference among the various varieties in the response to the different treatments. The auxin β-indolylacetic acid had no effect on ear emergence in varieties *N*.136, *T*.1145 and *T*.141, but produced a significant earliness in the variety *J*.192. The auxin α-naphthylacetic acid brought about a significant delay in ear emergence in the early variety *N*.136 and early-winter variety *T*.1145, it had no effect in the mid-winter variety *T*.141, but produced significant earliness in the late-winter variety *J*.192. The so-called anti-auxin 2,3,5-triiodobenzoic acid produced no effect in the varieties *N*.136 and *T*.1145, but brought about earliness in the varieties *T*.141 and *J*.192. Thus the effect of this so-called anti-auxin is in the same direction as the auxins and not opposite to the auxins.

Table 1. Time from Sowing to Ear Emergence in Days (Average of 24 Plants)

Sowing date for early variety December 19, 1955; for the other three varieties July 2, 1956

Treatments	Days from sowing to ear emergence			
	Early variety *N*.136	Early-winter variety *T*.1145	Mid-winter variety *T*.141	Late-winter variety *J*.192
β-indolylacetic acid				
500 p.p.m.	84·17	105·46	113·33	120·17
250 ,,	85·77	105·29	112·63	118·96
100 ,,	85·17	105·08	112·42	119·17
α-naphthylacetic acid				
500 p.p.m.	92·50	107·08	112·58	120·21
250 ,,	87·86	107·25	112·50	119·25
100 ,,	87·20	106·04	112·42	119·50
2,3,5,-triiodobenzoic acid				
500 p.p.m.	83·50	105·42	112·46	119·64
250 ,,	80·10	105·17	112·08	119·83
100 ,,	81·29	105·33	112·17	120·25
Controls	82·29	105·33	113·04	121·00
S.E. Mean	1·04	0·32	0·25	0·27
C.D. at 5 per cent	3·05	0·91	0·69	0·77

One clear result apparent from these studies is that the plant-growth substances in bringing about a modification in floral response have something to do with the normal flowering period of the rice variety. The normal flowering period of a rice variety again is intimately connected with its photoperiodic behaviour[7]. Generally early and medium-early varieties are either long-day or intermediate ones[8,9]; the early-winter, mid-winter and late-winter varieties are predominantly short-day plants[10,11]. The differential behaviour of a plant-growth substance on varieties of rice normally of different flowering durations is exemplified by taking one example. Thus in the present investigation α-naphthylacetic acid brings about a delay in the early and early-winter varieties, is without any effect in the mid-winter variety, while it brings about a significant earliness in the late-winter variety.

The other finding is that the earliness produced in these cases, though statistically significant, is of no agricultural importance. It is sharply in contrast with the results of Sircar and Kundu[12], who found a conspicuous earliness in a late-winter variety 'Rupsail' of Bengal by β-indolylacetic acid and α-naphthylacetic acid.

We are grateful to the Utkal University for award of the M. S. Gajapati Fellowship to one of us (G. S.) and a grant-in-aid from the Jnan Vijnan Parishad Fund, to Prof. B. Samantarai for providing facilities in the Department of Botany, Ravenshaw College, Cuttack, for carrying out this investigation, and to Prof. K. V. Thimann for helpful criticism.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 21

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (in collaboration with the ASSOCIATION OF BRITISH INSECTICIDE MANUFACTURERS, at 14 Belgrave Square, London, S.W.1), at 2.30 p.m.—Symposium on "Residues of Pesticides in Foodstuffs".

SOCIETY OF DAIRY TECHNOLOGY (in the Grand Council Chamber of the Federation of British Industries, 21 Tothill Street, Westminster, London, S.W.1), at 2.30 p.m.—Prof. H. D. Kay, F.R.S.: "The Early History of the Society".

UNIVERSITY COLLEGE, LONDON (in the Chemistry Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. D. P. Craig: "Theoretical Chemistry: Looking Before and After"* (Inaugural Lecture).

BRITISH COMPUTER SOCIETY (in the William Beveridge Hall, Senate House, University of London, Malet Street, London, W.C.1), at 6.15 p.m.—Prof. D. R. Hartree, F.R.S.: "The Machine's-Eye View".

INSTITUTE OF METAL FINISHING (joint meeting with the SOCIETY OF CHEMICAL INDUSTRY, at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. J. Edwards: "Accelerated Corrosion Testing of Chromium-Plate Articles—Sulphur Dioxide Test"; Mr. J. H. Hooper: "The Acetic-Acid Salt Spray Test".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. P. G. Mott: "Mapping Antarctica from the Air".

Tuesday October 22

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. C. W. Allen: "Astronomical Experiments Have Begun".*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. G. W. Bowdler: "The Measurement of High Voltages with Indicating or Recording Instruments".

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m. Prof. I. Düring (University of Gothenburg): "Aristotle's Scientific Ideas and their Transmission to the Latin West".*

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. W. S. Peart: "Some Biochemical Aspects of Hypertension"*. (Second of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on October 24, 29, 31, November 5, 7, 12, 14, 19, 21, 26, 28, December 3 and 5.)

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. R. Richards: "Nuclear Resonance".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Water Quality Problems in the United Kingdom". Chairman: Mr. Herbert W. Cremer. Speakers: Dr. Gordon Carter, Dr. B. A. Southgate and Dr. A. Key.

Wednesday, October 23

BRITISH COMPUTER SOCIETY (in the Great Hall, Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 3 p.m.—General Meeting of Business Group.

UNIVERSITY OF LONDON (in the Senate House, University of London, London, W.C.1), at 5.30 p.m.—Dr. Artur Hansson (Sweden): "Interaction of Heredity and Environment in Determining Quantitative Characters".*

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Three papers on "The Use of Colourings and Flavourings". (First of four meetings on "Some Nutritional and Allied Problems confronting the Food Manufacturer".)

Thursday, October 24

UNIVERSITY OF LONDON (at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5), at 3 p.m.—Dr. W. H. Thorpe: "Drive and Instinct in Animals".* (Further lecture on October 31).

LINNEAN SOCIETY OF LONDON (joint meeting with the ASSOCIATION FOR THE STUDY OF ANIMAL BEHAVIOUR, at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTE OF BIOLOGY, LONDON BRANCH (at 41 Queen's Gate, London, S.W.7), at 7.30 p.m.—Prof. P. C. C. Garnham: "Parasite Hunting in Brazil".*

Thursday, October 24—Friday, October 25

POLAROGRAPHIC SOCIETY (at the Cora Hotel, Upper Woburn Place, London, W.C.1)—Symposium on "Polarography in Industry".

Friday, October 25

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mrs. Eunice Belbin: "Some Experiments in Training Industrial Operatives".

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. S. L. Harris: "Dynamic Loads on the Teeth of Spur Gears".

ROYAL INSTITUTE OF CHEMISTRY (at the Manchester Town Hall, Manchester), at 7 p.m.—Dr. J. Bronowski: "Coal and Coal Chemicals in the National Economy" (Tenth Dalton Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. Michael W. Perrin: "The Constitution and Aims of the Wellcome Foundation".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

METEOROLOGICAL OFFICERS (5) (under 37, with either a first- or second-class honours degree (or equivalent) in physics, mathematical physics, mathematics or engineering; or a degree (or equivalent) in meteorology) in the Irish Meteorological Service—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (October 25).

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (preferably with a degree or equivalent qualification) to assist in the preparation and analysis of biological samples; radiochemical procedures will be employed—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (October 26).

LECTURER IN PHYSICS; and an ASSISTANT, Grade B, IN CHEMISTRY—The Principal, Nottingham and District Technical College, Shakespeare Street, Nottingham (October 26).

ASSISTANT LECTURER, Grade B (with good academic qualifications and experience in experimental and theoretical physics), IN THE DEPARTMENT OF PHYSICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 31).

FELLOW IN THE DEPARTMENT OF BIOCHEMISTRY; and a FELLOW IN THE DEPARTMENT OF PHYSIOLOGY, John Curtin School of Medical Research, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

LECTURER IN ORGANIC CHEMISTRY; and a LECTURER IN PHYSICAL AND INORGANIC CHEMISTRY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

POSTDOCTORAL RESEARCH FELLOW IN THE DEPARTMENT OF ORGANIC CHEMISTRY, for research which includes studies on the oxidation of phenols and investigations into the structure of complex paint phenolics—The Registrar, The University, Liverpool (October 31).

READER IN APPLIED MATHEMATICS; an ASSISTANT LECTURER (Grade B) IN PURE MATHEMATICS; and an ASSISTANT LECTURER (Grade B) IN APPLIED MATHEMATICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 31).

SENIOR LECTURER or LECTURER IN THE DEPARTMENT OF PHYSICS, Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

SENIOR LECTURER (with high academic qualifications and/or professional qualifications, some teaching experience, and preferably industrial experience) IN CHEMICAL ENGINEERING at Neath Technical College—The Director of Education, County Hall, Cardiff (October 31).

LECTURER IN BIOCHEMISTRY—The Secretary, The Queen's University of Belfast, Belfast, Northern Ireland (November 1).

SENIOR LECTURER or LECTURER (Grade I) IN PHYSICS; and a LECTURER (Grade II) IN PHYSICS at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 1).

LECTURER or ASSISTANT (Grade B) (with an honours degree) IN PHARMACOLOGY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.1 (November 2).

PHYSICAL CHEMISTS (with an honours degree or equivalent and experience in corrosion or a related field) at the Research Laboratories, Leatherhead, Surrey, for work on corrosion problems arising in nuclear and conventional power stations—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. N./432 (November 2).

SENIOR SCIENTIFIC OFFICER (CHEMIST) (with a first- or second-class honours degree or equivalent in an appropriate subject, wide experience of modern analytical techniques and experience in the use of radioactive tracers) in the Department of Scientific and Industrial Research, Research Group, Harwell, for work on radio-isotope application problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F.539/7A (November 2).

PHYSICISTS AND METALLURGISTS (with at least a second-class honours degree in physics or metallurgy or equivalent qualifications, and some postgraduate experience) in the Research and Development Branch of the Industrial Group of the U.K.A.E.A. at Culcheth Laboratories, Culcheth, Warrington, Lancs, to lead an intensified effort into the metallurgical and physical metallurgical problems of nuclear power—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2094 (November 4).

SENIOR LABORATORY STEWARD (with experience in the physics department of a university) IN THE DEPARTMENT OF PHYSICS, Univer-

sity College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 6).

Lecturers (2) (preferably with an interest in geophysics) in Physics at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 12).

Assistant Conservators of Forests (3) (with a thorough knowledge of forestry, an appropriate university degree, and preferably experience in practical forestry and botany) in the Forests Department, Ministry of Agriculture, Republic of the Sudan—The Sudan Embassy, Personnel Section, Cleveland Row, London, S.W.1, quoting Ref. "Assistant Conservator Forests 4/436" (November 15).

Assistant Lecturer in Geography at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, November 15).

Lecturer in Social Anthropology at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

Senior Lecturer or Lecturer in Chemistry at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 15).

Chair of Pathology tenable at St. Thomas's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 18).

Senior Principal Scientific Officer, to co-ordinate the work of the Plant Pathology and Entomology Departments, particularly in the field of virus diseases—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (November 20).

Chair of Archæology—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 23).

Lecturer in Zoology at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 30).

Research Assistant (with a university degree in chemistry and experience of research work in biochemistry or organic chemistry) at the St. Vincents School of Medical Research, Melbourne, N.6, for a research programme in the field of protein chemistry, under the direction of Dr. Pehr Edman—The Chief Executive Officer and Secretary, St. Vincent's Hospital, Victoria Parade, Fitzroy, N.6, Victoria, Australia (December 31).

Assistant Lecturer (physics graduate), to assist with the development of the new four-year Sandwich Course in Food Technology—The Principal, National College of Food Technology, Cranwood Street, City Road, London, E.C.1.

Chemist (with a degree or equivalent, varied experience in industry, and a knowledge of resins and their changing applications), to be responsible for answering inquiries of a chemical nature; the assessment of natural resources; and encouraging the development of new industrial projects—The Chief Executive Officer, The Scottish Council (Development and Industry), 1 Castle Street, Edinburgh 2.

Editorial Assistant (with a degree in mathematics or physics and some editorial and/or library experience) to undertake work in connexion with the publications of the Physical Society, and also to take charge of the Society's library—The Secretary-Editor, The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Lecturer; and an Assistant Lecturer, Grade B (with a good honours degree, together with teaching, research or industrial experience), in the Department of Applied Physics—The Clerk to the Governors, Welsh College of Advanced Technology, Cathays Park, Cardiff.

Lecturers, Grade IIa (honours graduates), in the Physics and Mathematics Departments—The Principal, Paisley Technical College, George Street, Paisley, Renfrewshire.

Research Assistant (preferably with some knowledge of, and interest in, protein chemistry), for research on plasma protease—The Pathologist, Institute of Orthopædics, Royal National Orthopædic Hospital, Brockley Hill, Stanmore, Middlesex.

Research Assistant (with a degree in zoology and interested in the development of cytological and/or physiological techniques) in the Department of Zoology—The Registrar, The University, Nottingham.

Research Fellow and a Research Scholar in the Department of Chemistry, for work on organo-silicon compounds—The Registrar, The University, Leicester.

Research Officer (Botany) (with a first- or second-class honours degree in botany, with some experience of research and a special interest in ecology and/or plant physiology) in the Department of Forest Research, Federation of Nigeria, to investigate the physiological factors influencing seed germination and seedling development of trees in Nigerian forests, entailing field studies as well as experimental work under controlled environmental conditions; and to undertake the general duties of a research officer—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/61/14/09.

Scientific Officer (with a first- or second-class honours degree in bacteriology or microbiology, or a first- or second-class honours degree which included chemistry and biology, followed by a post-graduate diploma in bacteriology) at the Water Pollution Research Laboratory (D.S.I.R.), Stevenage, for research on bacteriological problems connected with the treatment of sewage and trade wastes, and pollution of rivers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.180/7A.

Scientific Officer (with a first- or second-class honours degree in physics or equivalent), to carry out the investigation of a method for producing large short pulses of neutrons—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1598/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

International Committee on Science and Freedom. Bulletin No. 9: Apartheid—The Threat to South Africa's Universities. Pp. 50. (Manchester: Joint Secretaries, International Committee on Science and Freedom, Lime Cottage, 818 Wilmslow Road, 1957.) [78

Aluminium Development Association. Information Bulletin No. 22: The Brazing of Aluminium and Its Alloys. Pp. 36. (London: Aluminium Development Association, 1957.) 2*s*. [78

The Manual of Shrub Roses. Compiled by G. S. Thomas. Pp. iv+80 (12 plates). (Windlesham, Surrey: Sunningdale Nurseries, 1957.) 3*s*.

Forestry Commission. Bulletin No. 29: Shelterbelts and Microclimate. By Dr. J. M. Caborn. Pp. vii+135+28 plates. (Edinburgh: H.M. Stationery Office, 1957.) 17*s*. 6*d*. net. [78

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 25: The Rearing of Young Horses. Pp. 4. (Belfast: Ministry of Agriculture, 1957.) [78

British Coal Utilisation Research Association. Annual Report, 1956. Pp. i+72. (Leatherhead: British Coal Utilisation Research Association, 1957.) [78

Building Research Station Digest. No. 99 (June, 1957): Light Cladding—Part 1. Pp. 10. (London: H.M. Stationery Office, 1957.) 3*d*. [78

Library Association. Special Subject List No. 19: Electronic Computers in Business. Pp. 10. (London: Library Association, 1957.) 1*s*. 3*d*. [78

Department of Scientific and Industrial Research. Report for the year 1955–56. (Cmnd. 213.) Pp. 314. (London: H.M. Stationery Office, 1957.) 9*s*. 6*d*. net. [78

Report of the Committee on Administrative Tribunals and Enquiries. (Cmnd. 218.) Pp. ii+115. (London: H.M. Stationery Office, 1957.) 5*s*. net. [78

Annual Report on the Meteorological Office for the year April, 1956 to March 31, 1957. (M.O. 633.) Pp. 51+4 plates. (London: H.M. Stationery Office, 1957.) 3*s*. net. [78

British Electrical and Allied Industries Research Association. Technical Report L/T347: Polarizability of a Dilute Solid Solution of Dipolar Molecules at Low Temperature. By J. A. Sussmann. Pp. 7+3 figures. 9*s*. Technical Report L/T359: Models of Materials with Loss per Cycle Nearly Independent of Frequency. By H. Pelzer. Pp. 9+6 figures. 10*s*. 6*d*. (Leatherhead: British Electrical and Allied Industries Research Association, 1956 and 1957.) [78

Other Countries

Philips Laboratories. Contribution No. 115: World Directory of Crystallographers. Compiled by William Parrish. Pp. xvi+80. (Irvington-on-Hudson, N.Y.: Philips Laboratories, 1957.) [78

Indian Central Cotton Committee: Technological Laboratory. Technological Research on Cotton in India: a Résumé of the Work Carried Out at the Technological Laboratory during the period 1924–1956. Compiled by Dr. C. Nanjundayya. Pp. xvi+205+10 plates. (Bombay 19: Technological Laboratory, Adenwala Road, 1957.) Rs. 3. [78

Bulletin of the American Museum of Natural History. Vol. 112, Article 3: A Review of the Subgenus *Donacia* in the Western Hemisphere (Coleoptera, Donacidae). By Edward J. F. Marx. Pp. 191–278. (New York: American Museum of Natural History, 1957.) 1.50 dollars. [78

Institut des Parcs Nationaux du Congo Belge. Exploration du Parc National Albert. Deuxième Série, Fascicule 3: Biotopes de Haute Altitude: Ruwenzori, 1. Par Jean de Heinzelin de Braucourt et Henri Mollaret. Pp. 31+6 planches. (Bruxelles: Institut des Parcs Nationaux du Congo Belge, 1957.) [78

Transactions of the American Philosophical Society. New Series. Vol. 47, Part 2 (1957): Comparative Studies of North American Indians. By Harold E. Driver and William C. Massey. Pp. ii+165–456. (Philadelphia: American Philosophical Society, 1957.) 5 dollars. [78

University of California Publications in Botany. Vol. 29, No. 1: The Genus *Fitchia* (Compositae). By Sherwin Carlquist. Pp. 144+35 plates. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1957.) 2.50 dollars. [78

Somaliland Protectorate. Annual Report of the Geological Survey for April 1956 to March 1957. Pp. 1+13. (Hargeisa: Geological Survey, 1957.) Shs. 2/50. [78

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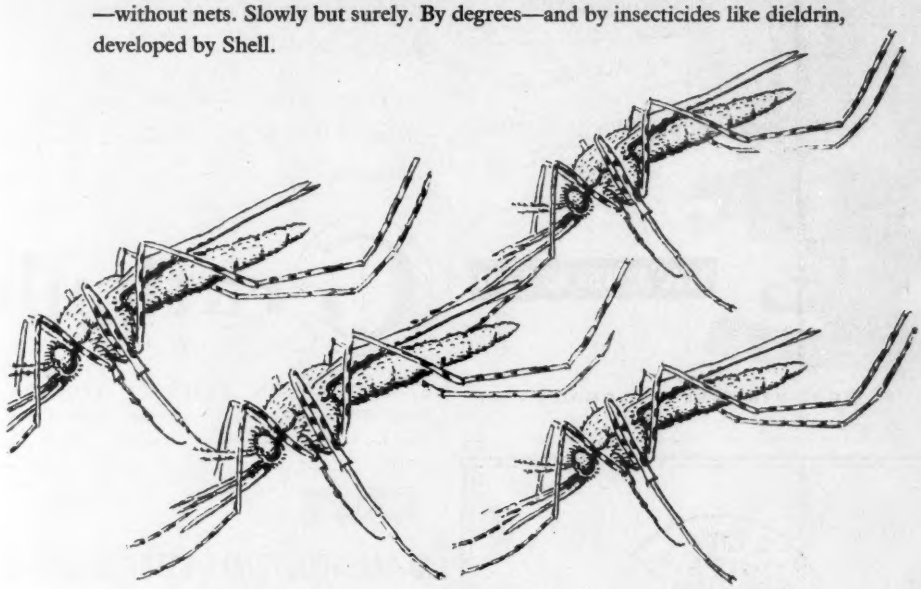

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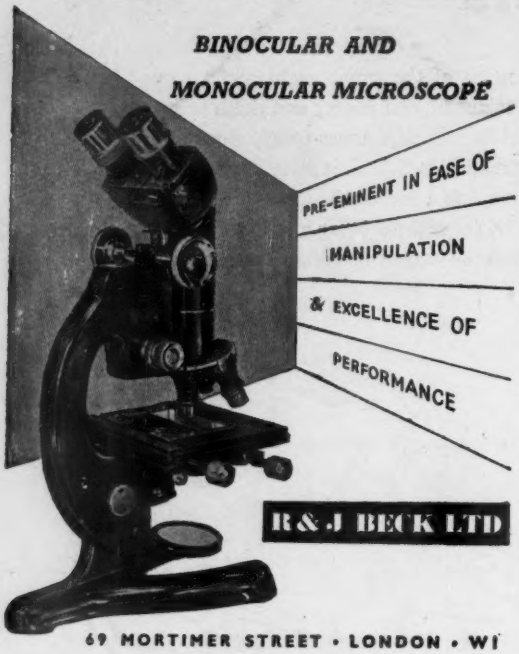

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